LECTURES

ON

AGRICULTURAL SCIENCE,

AND OTHER

PROCEEDINGS

OF THE

STITUTE OF AGRICULTURE.

LECTURES

ON

AGRICULTURAL SCIENCE,

AND OTHER

PROCEEDINGS OF THE INSTITUTE OF AGRICULTURE,

SOUTH KENSINGTON, LONDON.

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PREFACE.

THESE Lectures have been published in response to the urgent requests of many Agricultural Students in different parts of the kingdom, who are anxious to have copies of the Contributions to Agricultural Science which are, from time to time, brought before the Institute of Agriculture.

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FARM SEEDS:

And their Adulterations.

By W. CARRUTHERS, Esq., F.R.S., F.L.S.
Consulting Botanist to the Royal Agricultural Society.

A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

March 5th, 1883.

FARM SEEDS:

And their Adulterations.

The term Farm Seeds includes some objects which are not reckoned by botanists as true seeds. The seed potato, for instance, is not a seed, though on the farm it is so called. It is a tuber which reproduces the individual, after the annual plant has disappeared. In reality it is an underground branch, and each eye upon it is a bud. The branch is shortened and thickened, so as to contain a large supply of food for the young plant. In our deciduous trees, the tissues in the neighbourhood of the buds contain a supply of nourishment laid up in the last autumn to enable these buds to start into life, and obtain food for themselves. But the supply of starch in an ordinary bud is not sufficient to afford the plant food for independent life when separated from the parent, unless it be inserted into another allied tree, by the process called by gardeners, budding. But the potato has so large a supply of starch, that it is able to start the bud into life and to maintain the new plant, when independent of the parent. The quantity of starch is so large that we may divide the potato into as many pieces as there are buds or eyes, and sow them, and obtain from each a new plant. This story of the tuber of the potato may help us to understand the nature of the seed.

The seed may be said to consist of a bud with a supply of food stored up either within or alongside it, to enable it to start

into and maintain its existence separate from the parent. The necessary parts are the embryo, or bud, and the store of food.

This definition excludes the spore, which is homogeneous in structure, and which in germination throws out a leaf which may be looked upon as a feeding vegetable caterpillar. After it has obtained a supply of food, it produces the male and female organs from which are developed the perfect plant.

In the case of such seeds as clover, turnips, and allied plants, it is found that the whole of the food is laid up in the bud itself. The two large seed leaves—the cotyledons—are enormously developed and contain the starch on which the young plant is to live. The split pea, obtained by removing the skin, and separating the cotyledons, affords an instance of the enormous development of the seed leaves, each half representing the swollen leaf filled with starch.

The structure of the seed of wheat was well illustrated by the lecturer, who exhibited a beautifully constructed model of a grain of wheat, kindly lent by the Lords of the Committee of Council on Education. This model he separated into its various parts, explaining each as he did so.

The little bud is situated towards the base in the front of the seed, where the surface is somewhat wrinkled. This consists of a minute axis crowned with leaves above, and terminating in a radicle below: these constitute the embryo. By the side of the embryo and forming the great bulk of the seed is the starch or food for the young plant. This is laid up in cells, composed of a substance called cellulose, having the same chemical constituents as the starch, but differing in its molecular structure. These little bags contain in the ripe seed little except starch; the interspaces being occupied with the hardened protoplasm forming the nitrogenous element. The starch is composed of carbon, hydrogen and oxygen, and in addition to these elements, nitrogen is present in the protoplasm which lines the walls of the cells.

This protoplasm is the active agent in the whole life of the plant. It is the operator, so to speak, in the cell. It takes the inorganic food of the plant and builds it up into starch, and continues this process until the whole seed is filled.

When the protoplasm, in the germinating seed becomes active, it converts the starch into dextrine or British gum, in which state it is able to pass through the cell walls and build up the young plant. The plant is thus maintained during the earlier part of its existence, and sends forth its leaves into the air, and its roots into the ground at the cost of this food and until it is able to obtain food for itself.

In looking forward to the production of a crop the farmer may desire to secure the peculiarities of the individual, or of the variety, or of the species. The peculiarities of the individual can be obtained only by producing independent plants from portions of the individual sought to be propagated. This is done in the case of the potato.

In seeking to perpetuate in his crop the peculiarities of the variety, the farmer must depend upon the grower of the seed; for varietal peculiarities are not generally so expressed in the seed that they can be identified, even with the most careful examination. This refers to the varieties of the cereal crops, to turnips, cabbages, and other green crops.

In dealing however with species, there is no difficulty in determining the character of the seeds which are to be employed for the future crop. This may be best illustrated by reference to the seeds employed in producing pastures; for the various species belong often to different and widely removed genera, and present characters which are apparent even to the naked eye; while the seeds of the more closely allied species are easily separated by a microscopic examination.

The farmer's great object is to secure good seed. First, it should be free from weeds. This caution needs scarcely to be specified in dealing with the seeds of cereals. They seldom contain what we usually understand by weeds. But some care should be exercised in the selection of these seeds, so as to secure their freedom from less obvious, but perhaps more dangerous, enemies.

First amongst these is the presence of minute fungi. The minute spores or seeds of bunt are seldom present in sufficient quantity to be obvious on even a careful inspection of the seed.

Yet this is a most dangerous parasite, and to prevent its appearing in the new crop measures should be taken to destroy it before the seed is put into the ground. Farmers generally have the conviction that blue vitriol wash effectually secures this, and the testimony that I have received seems to support this conviction. But I prefer the use of a more efficient agent, such as carbolic wash, which would certainly destroy the minute spores, but it requires to be carefully applied to prevent it from destroying also the embryo of the seed itself, as has taken place in cases which have come under my notice.

The farmer should carefully avoid allowing any purple grains to be present in his seeds. These grains are filled with an enormous multitude of minute worms, which, like the seed itself, remain in a dormant condition until the moisture and heat of the spring revive their activity, and spread them over the field at a time when the young plants are in a condition to suffer from their attacks.

Let me also mention here a parasitic disease, happily very rarely found among cereals, but often producing great injury in pastures. I mean the fungus called ergot. The black body which appears to take the place of the grain in some grasses, and which has often produced great injury to breeding stock, is very frequent amongst some seeds. It is sufficiently large to be observed and avoided when it is met with in rye grass. Its small size in fiorin causes it to be overlooked. But notwithstanding its smaller size, it is equally dangerous as a source of infection in the grasses of a new season, with the ergots of the larger grasses. It is very difficult to get a sample of fiorin free from this fungus.

It is difficult to entirely escape the presence of a certain proportion of weeds, though the difference in the form of the seeds of most weeds from those of grasses causes them to be less frequent in samples of grass than in the so-called artificial grasses or clovers. It is very rare to find a sample of clover entirely free from weeds. The seed most commonly met with is that of the rib grass; a plant not unfrequently sown, on account of its own supposed merits, as an ingredient in pastures. I have never,

from my own observation, or from trustworthy testimony, seen any reason for reckoning this plant anything else than a weed.

The seeds of sorrel are common, and also various seeds of the Caryophyllaceous genera, such as catchfly, chickweed, &c.; seeds of self-heal and cranesbill and dock, &c.; all these weeds occupy ground unnecessarily, if not injuriously—ground which should support valuable clover plants. They are not so pernicious to the crop as the parasitic dodder, which lives on the clover and completely destroys it for feeding purposes. The dodder seeds are too frequently met with in foreign samples of clover; but there is little excuse for their presence, as the seeds are so small that they can easily be separated by the sieves which are used by all careful seed merchants.

Next, the farmer should see that the seed he obtains is free from deliberate, or it may be accidental, adulterations. The annual loss to the farmers from adulterations must be enormous; and the conduct of those in the trade, who deliberately adulterate their seeds, cannot be too strongly condemned.

To give some notion of the extent to which farmers suffer from adulteration, let me mention a few instances which have come under my own observation. One of the most valuable grasses is the meadow fescue; but the seed of this grass in size, form, and weight agrees so exactly with that of perennial rye grass, that it is next to impossible to discriminate the two with the unaided eye. The price of the meadow fescue is about 1*s.* per pound, while the rye grass costs no more than 3*d.* a pound. It is obvious that the money advantage to the tradesman of introducing the seed of rye grass into his fescue and selling the mixture at the higher price is very great.

Of 32 samples which I have recently examined only 4 were free from rye grass, 21 had more than one-tenth, 5 more than one-third, and 2 more than one-half of rye grass.

But this is not the only grass which is systematically adulterated. The seeds of molinia, a wiry grass found on wet moors, are extensively employed to adulterate the smaller seed of grasses such as sheep's fescue, dogstail, &c. In some cases within my own experience they have constituted one-half of the bulk of

such seeds. And the useful yellow oat grass is very rarely free from the closely resembling seeds of the mountain hair grass; indeed the seeds of this worthless grass are often supplied instead of those of the oat grass.

In these instances it is impossible to believe that the adulterations have not been deliberately introduced with the view of putting money into some one's pocket.

The species that are employed for adulteration do not grow naturally in company with the plants whose seeds are adulterated. There must therefore be independent collection and deliberate mixture.

Indeed, I have been credibly informed that rye grass largely grown in the North of Ireland is exported to Germany and there mixed with the seeds of meadow fescue and returned to Britain as fescue and of course paid for at the higher prices.

I hope the day is not far distant when the seed merchants in this country will, as a body, qualify themselves to recognise these adulterations, and so prevent their distributing worthless grasses at high prices, as they do at present, I believe without knowing it. This would not be a difficult matter, for the characters by which the various seeds may be distinguished, though they may not be apparent to the naked eye, are easily determined by the use of the microscope. In the case, for instance, of the fescue and the rye grass, it is easy to separate them by recognising the cylindrical form of the secondary stalk at the inner base of the seed in the case of the fescue, as compared with the triangular form in that of the rye grass.

Further, the farmer should see that his seeds are fully ripe. The best seed for the miller is also the best seed for the farmer. For the nitrogenous elements which make the miller's seed valuable for bread, make the farmer's seed valuable for producing vigorous and healthy plants. Badly ripened seeds, and seeds which are deficient in nitrogen, start in life the young plant produced by them under disadvantageous conditions.

Some seeds are almost invariably collected in an unripe condition. This is especially the case with that important pasture grass, meadow foxtail. Farmers desiderate the silvery grey

colour in this seed, which is best secured by the grower when he collects it before it is ripe. The result is that a large proportion of this seed is of no value for growing purposes. Out of 20 samples I have lately examined, 2 did not contain a single seed capable of germination, 8 did not germinate one-tenth, 5 less than 50 per cent., and only 5 over 50 per cent.

If purchasers would look more to the weight of this seed and be indifferent to its colour, there is no reason why this grass should not germinate as well as any of our other pasture grasses.

And still further, the seed should be new. As long as the conditions favourable for germination are withheld from the seed, its life remains dormant. But this life cannot be indefinitely prolonged. The persistence of life is due mainly to the protective coverings of the seed, and to some extent to the quality of the food stored up for the use of the young plant. In all aquatic plants, the seeds of which are exposed to conditions unfavourable for their preservation, the protective coverings are largely developed, and the seeds are capable of germination after having been kept for a long time. The oldest seeds which have germinated, as far as I know, are those of the Nelumbium Lily of the Nile, which, after having been preserved in the British Museum for somewhat over a century, produced living plants.

In the case, however, of the seeds of cereals and of grasses generally, there is no special protection to preserve the embryo from complete desiccation and consequent destruction. And as a matter of fact, seeds of wheat have failed to germinate after being kept seven or eight years, or ten years at the outside. The decrease in the numbers annually germinating, determined by numerous experiments, shows that about 85 per cent. grows of two-year-old seed; 60 per cent. of three-year-old seed; 30 per cent. of 4 years, and 15 per cent. of 5 years.

It is then very important to secure seeds from the preceding harvest. This cannot, however, always be obtained, especially if we must trust to the somewhat uncertain weather of our English harvests requiring us to make up the defects of one year by the superabundance of a previous season. But when

foreign seed is purchased there ought to be no difficulty in securing that the whole bulk consists of the newest seeds. And the prejudice that exists in some minds against foreign seeds is without any just foundation.

It is not possible for me to urge too strongly upon farmers to secure clean and pure seed of the best quality, and of the last harvest. They cannot otherwise hope to obtain a good crop of vigorous plants, producing a fruitful harvest or a nutritious pasture. The worthless grasses, and still more worthless, if not actively injurious weeds, so frequent in pastures, would disappear, and heavier crops of the best quality would be secured.

CONDITIONS INFLUENCING LAND DRAINAGE.

By PROFESSOR J. WRIGHTSON, F.C.S.
President of the College of Agriculture, Downton.

A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

March 12*th*, 1883.

CONDITIONS INFLUENCING LAND DRAINAGE.

It is of the utmost importance that land should be thoroughly drained, for no other improvements can be effective until the land is freed from the stagnant water.

The question may be asked "Why should drainage be such an excellent thing?" Water is one of the most essential conditions of plant life—indeed, 90 per cent. of most vegetables consists of water. "Why then should you be so anxious to get rid of the water?" In reply to this question we may remark that the object of draining land is not so much to deprive the land of water, as it is to increase the amount of water contained in the ground.

Well-drained land is more friable than wet land, and in accorddance with this fact the porosity—or power of the soil to retain moisture—is increased. The ground, in fact, becomes like a sponge, and the water is *gradually* given up to the plant. A well-drained field allows the water to pass through it very readily, but an undrained field soon becomes "puddled."

The benefits of drainage are rendered more evident by the following considerations.

There is a change in the conditions under which water exists in the soil. By draining, not only is a larger amount distributed throughout the soil, but the water is changed from a condition of stagnancy to one of movement.

Stagnant water excludes the air, and thus the great purifier—oxygen—is kept from doing its necessary work.

Water in a state of stagnancy prevents the development of

carbonic acid, in the interstitial atmosphere of the soil, and as a consequence of this, less of the mineral constituents of the soil are rendered available for plant life.

Again, when the ground is surcharged with water a loss of warmth ensues, by reason of evaporation from its surface. The enormous amount of heat thus lost has been calculated to be equal to the combustion of twelve hundred-weight of coal per acre every day. In summer the surface water is kept warm, and as it is lighter than the water beneath, it remains at the top, and thus prevents the heat from penetrating to the lower strata.

The average difference of temperature between drained and undrained land has been found to be 10° F. This is equal to the average difference between the temperature of February and that of May.

In winter, on the other hand, the surface becomes cool, and the cold water being specifically heavier will sink; at the same time the warmer water rises to supply its place. Thus we obtain a cold current of water downwards, and a warm current in an upward direction, and thus the entire mass of soil is chilled.

"Shrinkage" in the case of a drained soil may amount to as much as 5 per cent. of its bulk. It is well known that land which is drained soon becomes dry after a fall of rain. This drying is accompanied by contraction of the soil, and when again subjected to rainfall it undergoes expansion. This alternate contraction and expansion causes a certain amount of pulverisation, and thus the land gains an immense benefit.

To give an idea of the amount of contraction which sometimes takes place, Professor Wrightson instanced an observation he made in 1876, after a long spell of dry weather. In this case a walking-stick was buried in some of the cracks which formed a kind of network over the whole field.

A great change is observed in the condition of clay lands which have been subjected to drainage. The blue clay becomes red, or, in other words, the ferrous oxide is converted into the higher form—ferric oxide.

Another advantage of drained land over undrained land is that gained by the roots, which are enabled to penetrate to a

greater depth, and draw their food from that part of the soil from which, in an undrained field, they are debarred.

The farmer should also be influenced to drain his lands by the fact that an *earlier harvest* is obtained. In some cases harvest has been two weeks earlier after thorough drainage. The crops also are larger and of a higher quality.

Another consideration in favour of drainage is that there is a great saving of horse labour, because the number of working days throughout the year is increased, for a farmer who has well drained his land can get to work with his tillage operations, while the man whose fields are undrained is waiting for his land to dry.

There is a great freedom from certain plant diseases on drained soils. These diseases, such as blights, mildews, and rusts, spread rapidly on wet ground.

The health of the live stock is improved by drainage of the land on which they feed, and the general health of the population in the district is also improved.

The "reciprocal action" of drains was next alluded to; and the lecturer was of opinion that on an average clay soil a distance of 18 feet apart was usually sufficient to establish reciprocity of action.

Again, the depth to which land must be drained varies. On a stiff clay it will be less than on a sandy soil. It must be borne in mind in connection with this point that in order to obtain 18 inches say of dry soil it is necessary to drain to a depth of 2 feet 6 inches or even 3 feet. There is now a tendency with farmers to return to the old method of shallow drains, as they are considered to be more efficient in their action.

The part of the soil containing the water which requires to be removed is called the reservoir, or section of supersaturation, the upper surface of which is termed the "water-table." Thus the main object of drainage may be said to be the lowering of the "water-table."

In the course of the lecture Professor Wrightson exhibited a diagram, and explained the mode of action of Elkington's

system of draining, which was discovered in 1763 while an attempt was being made to get rid of the water with which the fields were surcharged.[*]

This system is applied to the greatest advantage on those lands which consist of alternate strata of permeable and impervious beds giving rise to springs.

BEES

IN RELATION TO

Flowering Plants and Fruit Production.

By F. CHESHIRE, Esq., F.R.M.S.

A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

March 19*th*, 1883.

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BEES

IN RELATION TO

Flowering Plants and Fruit Production.

Mr. Cheshire, after referring incidentally to the greatly increased profits now attainable by bee culture in consequence of our improved methods of management, remarked: If we take our stand before a flourishing hive on a fine summer day, we note that the busy workers, as they settle, at their return from their excursions in the fields, bear in numerous instances variously coloured pellets on the tibia of their hind legs. The ancients supposed these masses to consist of wax, and even Reaumur fell into this error, referring to these pellets as "la cire brute." We now know perfectly well that they are composed of multitudes of pollen granules which have been gathered by a process we shall hereafter examine, and the use of which we shall presently see, and that wax is not collected but secreted by glands situated beneath the abdomen. Could we follow these workers into the darkness of the hive and here observe their movements, we should find that they walk up the sides of their combs seeking first a cell into which the pollen may be appropriately placed, and they then turn to another, either empty or already devoted to honey, and into that they discharge from their honey-sack the nectar which they have secured from the honey-glands of the blooms visited. Two questions now present themselves to us.

Why do the bees so industriously gather these substances? and why do blooms provide them? It is to the second of these questions that we must devote our most serious attention, but the first if we would really understand the second must not be overlooked. If we were to proceed to examine the combs of the hive just referred to we should find many hundreds of their cells, containing each a tiny pearly coloured egg about the $\frac{1}{14}$ of an inch long and the $\frac{1}{70}$ of an inch in diameter. These eggs have been deposited by one insect, called, although very inappropriately so, the queen, for she in reality exercises no authority, and when old and fading is turned out in favour of a more vigorous successor. This mother bee, for so we may more accurately designate her, is capable of depositing no less than from two to three thousand eggs daily during the breeding season. She inserts her abdomen into a cell and in two or three seconds withdraws it, when the egg is found adherent to the cell-base. This duty of ovipositing is so onerous that she is excused all care of her numerous progeny, which is attended exclusively by the workers, formerly but falsely called neuters, for they are really females but with their reproductive organs aborted. The egg kept warm by heat constantly produced by oxidation of honey in the bodies of the workers develops within it its germ, and in about three days a very small grub emerges, with but imperfectly formed mouth, no distinguishable eyes, and no organs of locomotion. It is a necessity that food should be brought to it as it lies at the bottom or back of the cell. The workers acting as nurses now sedulously tend it, preparing in their bodies a highly nutritious food resembling thin arrowroot and elaborated from water, honey, and pollen. The two latter we have previously traced to their origin, and it needs only now be said that the first of these is a true force-former, giving to the grub energy for movement and for the vital processes to be continued within it, while the pollen is a true tissue-former, being rich in nitrogen and containing potash, phosphorus, and sulphur salts. The food is poured over the body of the grub by the nurse, and so liberally that the bantling literally floats in it; one side of the body, however, always remaining dry, so as to be capable of taking in a due supply of air through the eleven spiracles or

breathing-holes which may be traced in a line along its side. The imperfect mouth has its work supplemented by an ability to absorb aliment by osmose through any portion of the skin. Rapid growth is the result, and soon a large fat "gentle"-like creature two-thirds fills the cell. The ever watchful workers at this point commence to imprison it by placing over the mouth of its cell a cover, technically called the sealing, which is composed of pollen grains and wax shreds. and which is pervious to the air, so that the needed amount of oxygen may reach the grub within. The grub also makes preparation for the wonderful transformation which awaits it, by building over itself a silken cocoon. During twelve days developments and alterations are continued, which our time will not permit us to follow in any detail, but in the end changes of a most radical nature are effected; the nervous system is completely recast, instead of a chain of pretty equal ganglionic masses running the length of the digestive tube, nerve-centres are established in the neighbourhood of the insertion of the wings and legs to give to these parts the abounding energy they require in the perfect insect. The mouth and eyes have each now considerable ganglia, and the sting is also provided with its source of stimulus. Legs marvellous in form and adaptation, and carrying, cleaning, gathering, feeling and modelling appliances, are evolved. Four beautiful wings are provided, new glands have made their appearance, eyes of great complexity are now possessed, and last but not least a tongue has presented itself, so wondrously perfect and minutely delicate, that some points in its structure are until now furnishing the microscopist with unsolved if not insolvable problems. In a word, the soft-bodied, helpless grub has become a bee. Time forces us to leave this tempting subject, simply remarking that we have answered our first query, for we now see why honey and pollen are gathered. Let us now address ourselves to the second, and inquire why the blooms furnish these substances to their insect visitors.

Blooms are produced by plants in order that seeds may follow, and so the race be continued. Two parts are essential to this reproduction—the anther [1] and the pistil, the latter very generally

[1] Illustrations were here given on the black board, and references made to a very fine set of diagrams.

occupying the central position. The anther is usually a double-celled pouch, the contents of which by segmentation breaks up into a number of perfectly similar parts called pollen grains, which, though minute, are complex in structure. When these are mature the anther splits or dehisces, and the pollen escapes, but it needs in some way to be applied to the termination of the pistil called the stigma. When this application is effected, the pollen grain absorbs moisture, its interior portion swells, and actually throws out a tube which often grows to a great length in making its way towards the unimpregnated nucleus of the ovule which is situated in the ovary at the base of the pistil. In this nucleus a large cavity filled with protoplasm has developed, called the mother-cell, within which we find the embryonal vesicle to which the contents of the pollen grain is transferred by the channel of the pollen-tube. This is fertilisation, and upon it depends the production of seed, for the new individual plant has its beginnings from this interfusion.

An examination of most blooms will show that the essential organs before referred to are so placed that an accidental or unaided transfer of pollen to stigma is unlikely, and where this arrangement of parts is not found it frequently occurs that the anthers ripen and dehisce much before, or not until some time after, the stigma has so matured as to be ready for pollination. In the former case, as we may observe in the common garden nasturtium (*Tropæolum majus*), the pollen is all carried away by insects by the time the stigma presents itself, so that if fertilisation be effected it must be through the bringing of pollen from other blooms still shedding it. Insects are the means which accomplish this, and to secure their visits, the blooms spread them a banquet.

After pointing out the special adaptations to cross-fertilisation found in a number of blooms, the Lecturer turned the attention of the audience to orchard fruits.

The apple, he remarked, is called by the botanist a pseudo-syncarpous fruit, because it may be regarded as five fruits gathered into a unit by an envelope formed by a development of the calyx. If an apple be cut across we see five compartments or dissepiments in the core, each one of which should contain pips or seeds. The bloom which preceded the

fruit had five stigmas, each one of which communicated with a dissepiment and required an independent fertilisation. Bees seeking honey would, by getting their breasts (furnished as they are with abundance of long webbed hairs) thoroughly dusted with apple pollen and flitting to a bloom whose stigmata had reached the receptive condition, bring about fertilisation. It would however frequently happen that three or four of the stigmata only would be pollinated. In this case an apple, though an imperfect one, would be produced. Trees agitated by the winds frequently drop a quantity of their fruits, hence known as windfalls, but the actual cause of this dropping is in by far the largest number of instances defective fertilisation.

In an examination made some time since of a large number of windfalls, less than four per cent. were found to have fallen through injuries traceable to insect pests, while the remainder had received pollination in from one to four dissepiments only.

Fertilisation is followed by a determination of nutrition towards the seeds, and the parenchyma of the apple as a protective envelope gathers around them. If therefore we cut a defectively fertilised apple across the middle, we find a hollow shrunken side lying over the unfertilised portion of the core. These facts taken together show conclusively how completely our apple crop is dependent upon insect agency, and amongst these the hive-bee takes the most important place.

In the case of the strawberry, the parts popularly denominated seeds which crowd its surface are really the fruits technically called achenia, while the strawberry itself is really a succulent development from the flower-stalk. The stigma each of the achenia carries must be fertilised by insects which are attracted by the honey secreted by a ring of glands situate at the base of the strawberry. The anthers are wide set, and as the insect walks around the bloom applying its tongue to the circle of glands, one side of its body is dusted with pollen from the anthers, while the other is applied to the stigmatic faces. In passing from bloom to bloom it frequently reverses the order of its progression, sometimes going round by turning to the right and sometimes to the left. As a result the pollen gathered up on one side of the body is probably transferred to the stigmas of the next flower visited. As

in the case of the apple, so here, fertilisation determines nutrition. The placentæ of the fertilised achenia increase enormously, the strawberry grows and matures, but where any of the stigmas escape impregnation, there the strawberry remains without growth while other parts are rapidly increasing around it. The examination of a few fruits would be sure to supply examples where in circumscribed spots no progress has been made since the first full expansion of the bloom. The achenia are close set and green, and the flesh of the strawberry is there crude and hard, while the rest is sweet, soft, and luscious. Imperfect insect work is again the explanation, bringing before us the remarkable fact that no perfect strawberry can be produced without perhaps from three to four hundred independent fertilisations, accomplished it may be by the busy hive-bee, which, in filling the niche in which the great Creator has placed it in unselfishly labouring in providing for the wants of its younger sisters, is unconsciously supplying to its master not honey only, but honey and fruit.

The raspberry, although of another type, somewhat resembles the strawberry in the multiplicity of its stigmas (sixty or seventy to each bloom), the wide setting of its anthers (about eighty or ninety in number), and its circle of honey glands. Similarly too the insect visitor in seeking nectar passes between the anthers and stigmas, applying its right side to one and its left to the other. Each seed fertilised by these visits is soon surrounded by the luscious envelope which protects the seed from injury, and makes the manufacture of raspberry jam a possibility. These rounded red masses with their inclosed seeds, technically called drupels, are never formed unless fertilisation has taken place; neither ripening nor growth being possible in its absence. We see then in an aspect which may be new to many of us, that this wondrous scheme of nature has correlations which we never could have anticipated, that a large part of the insect world is complementary to plant life, and plants in turn the sustainers of these insects, and that man, although be can plant his trees, is in no small measure dependent for a crop upon the assistance of those little labourers, who, by their unconquerable industry, supplied his table with sweets for long ages before he discovered the uses of the sugar cane.

NATURAL AND ARTIFICIAL GRASSES,

Their Variations in Form and Quality.

BY PROFESSOR JAMES BUCKMAN, F.L.S., F.G.S.
BRADFORD ABBAS, DORSET.

A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

April 2nd, 1883.

NATURAL AND ARTIFICIAL GRASSES,

Their Variations in Form and Quality.

THE term "grasses" is not always well understood. Among farmers the term is extended to include other plants cultivated for forage or fodder, and even many plants bearing the name grass are not in reality grasses; as for example ribbed grass, whitlow grass, supposed to be a specific against whitlows, and a plant of the same genus as the horse radish, which is called scurvy grass.

The structure of grasses next occupied the consideration of the Lecturer, who illustrated his remarks at this point by reference to a diagram which he sketched on the board. The roots of grasses are fibrous, and the stems are mostly cylindrical and hollow, but sometimes flattened and solid. From the node proceeds a sheath, which starts from the upper part of the joints or nodes of the stem. The formation of the node was then explained, and a method of distinguishing sedges from true grasses was pointed out. If the leaf of a true grass be pulled downwards it leaves the stem without being torn, thus showing that it merely envelops it, but if the same operation be performed with the sedge the base of the leaf becomes torn.

Grasses usually have three stamens, some have two, while others have but one. The bristle-like appendage found on the glumes is termed the awn of the grass.

Grasses are divided into two classes—natural grasses, those of

old meadows, and artificial grasses, those sown for the purpose of shifting crops. Natural grasses belong to the class *Glumellæ*, their floral envelopes being formed of glumes or pales; these are the true grasses.

These grasses differ in form and in their feeding qualities. Various kinds of grasses are found in different positions. Some are found on dry soils, and others on rich soils with abundant moisture, while others again abound and flourish in marshy districts.

The causes of the differences between good and bad grasses, requires investigation.

With respect to the form of grass, the difference consists simply in the arrangement of the various organs, and not in the presence of additional organs. The pedicles, for instance, may be long or short.

If the leaves of grasses be carefully examined, some will be found to have minute spiculæ upon them, which are very hard, and are mostly composed of silica. The presence of these is indicated by the roughness to the touch. As this substance is not largely required by the animals in their systems, it indicates a grass of inferior feeding quality. Again other leaves may be covered with long more or less silky hairs. These consist of non-succulent vegetable fibre, and render the grass worthless as a food. The most valuable grasses for feeding purposes will be those which do not exhibit either of these external additions of hairy fibre or silica. In good grasses, near the node, will be found a small quantity of saccharine matter. This is indicative of a high feeding quality. The *Arrhenatherum avenaceum* will be found to contain a bitter substance in the place of the sweet matter, and will be of poor quality. This grass is not acceptable to cattle, and should not be used in artificial mixtures of the grasses.

The grasses whose leaves exhibit a fine grain, and are developed without much woody fibre, and are sweet at the nodes, will be of the highest feeding character.

Grasses vary very greatly with respect to their feeding qualities. Sheep take readily to some of the fescue grasses which grow in

mountainous pastures; and one species is called sheep's fescue from this fact.

Sheep's fescue and allied species and varieties are also grown in the lowlands, and on sandy soils. On clay soils, a poor species of grass is met with of a coarse habit, and of no value as food, and are hence called sour grasses, the *Avena pratensis*, *Alopecurus* and others, are examples.

Professor Buckman referred to the fallacy which some farmers entertain, viz:—that if animals were allowed to eat the grass in the field, the land would be sufficiently enriched by their manure. They forget that much of the substance drawn by the grass from the soil will be appropriated by the animal in its own system. Hence the necessity for applying manures to pasture lands.

There may be said to be only about 10 or 12 species of good feeding grasses, and there are about 20 species of inferior quality usually met with in meadows, and the well-being of these two sets marked the nature, well or ill-doing, of a pasture with the utmost exactitude.

To show that a great number of grasses may abound in the same field, the Lecturer said that he had discovered as many as 40 different species in the same meadow. Some grasses, which only grow in damp situations, by their presence in a field indicate the necessity for drainage.

The Professor concluded his lecture by explaining how a collection of grasses might be made, and pointed out what a large fund of instruction was to be derived from this course of procedure.

During the lecture, specimens of the various grasses and their seeds were handed round for inspection. These admirably arranged specimens were kindly lent for the occasion by Messrs. Sutton, who at the request of the lecturer were heartily thanked for their kindness.

DAIRY MANAGEMENT.

By PROFESSOR J. P. SHELDON,
Professor of Dairy Farming in the College of Agriculture, Downton, near Salisbury.

A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

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DAIRY MANAGEMENT.

DAIRY farming includes the raising of cattle for meat, and the production of milk, cheese, and butter; and is a more important subject in a country like England than is generally supposed. A great amount of capital is involved in this industry, and it is a matter for regret that the number of cattle seems to be diminishing, a fact calculated to inspire us with more or less alarm.

In 1881 there were 9,905,013 cattle in the British Islands; while in 1882 there were 9,832,417, showing a decrease of 72,596. There was an increase in the case of Ireland.

This increase or decrease of cattle deserves attention from those in power. Many foreign diseases, as for example the foot-and-mouth disease, have been repeatedly introduced in spite of the precautions taken at the ports of landing, and have frequently spread over the land. In Scotland it has lately spread so rapidly that all fairs and markets have been closed, and in England, the counties of Gloucestershire, Worcestershire, and Cheshire, are entirely closed to cattle. This is one result of diseases sent from foreign countries.

It is said that if we exclude live cattle the price of beef will be greatly increased. The Lecturer believed this to be a great mistake, for the countries supplying us from abroad could send the dead meat. It had been calculated by Mr. Howard, M.P. for Bedfordshire, that there was more of our own production of

meat destroyed by this and other imported diseases than the sum total of the meat obtained from other countries; for even when our animals recovered, they had lost their flesh, and this in a sense was equivalent to death.

Dairy farming cannot be expected to prosper while these diseases are allowed to stalk through the land. There is no encouragement for dairy farmers to restore the numbers of cattle under these circumstances.

Dairy farming is more profitably conducted on sound soils which do not require artificial drainage. But there are plenty of soils requiring artificial drainage which may be made almost equal to sound soils in the matter of dairy farming if the drainage be properly carried out, and there are also the alluvial soils and others on various geological formations that are laid dry with comparatively little trouble and expense.

Where the soils are rich by nature, whether drained or naturally dry, dairy farming may be made more productive, but it seems to be conducted to the greatest advantage on those soils not requiring artificial drainage.

It has been said that fertilising by bones and other matters rich in phosphates has made cheese-making more difficult. The reputation of Cheshire cheese has somewhat fallen away. The farmers, it was said, made the land so rich in phosphates that cheese-making became a difficult thing. The Lecturer thought this a very extraordinary solution of the difficulty, and he made special inquiry concerning this allegation, and found his own ideas were corroborated, viz :—that too many bones can hardly be used, and the richer they made the land, the better the cheese became; provided it *were properly and intelligently* manufactured. These terms, applied to cheese and butter making, involve what is understood by the word "Science."

Cheese-making diminishes the fertility of land, but it does not rob the land so much as the raising of young stock, though it draws upon it more than in the fattening of stock; for the frame of the young animal has to be built up from the phosphates in the soil, and these are provided either naturally or by the bones applied as manure. Thus the soil is more diminished

in fertility, and requires more assistance, by raising young stock on it than by milking, and still more by milking than by fattening stock.

On many soils bones are found to be the best fertilisers used. They are rather slow in their action, unless properly dissolved, but they last a number of years. One of the best means of improving the land is by the consumption of linseed-cake and cotton cake; the animals are improved thereby, and the land also reaps a considerable and lasting benefit from the residue of such food.

It may have been noticed in the newspapers that statements have been made to the effect that land in this country is being more and more laid down in permanent grass. The tendency now is to plough less and have more of the land in pasture. No doubt the seasons we have experienced have greatly contributed to this. This is a serious matter in many parts of England, but in others, perhaps, it is the best because the most economical course to pursue, reducing the cost of labour, and of general wear and tear.

In France, Central Germany and Denmark, dairy farming is carried on very extensively in conjunction with arable cultivation. There are farms where a large number of cattle are kept, and yet there are no permanent pastures. The animals are fed in stalls, and their green food is carried into their stalls, a small field being allowed them for exercise.

Professor Sheldon believed it might be taken as an axiom that "land will produce more food, if kept stirring, than if it lie still."

Some of the grand old pastures in the best parts of England and Ireland have never been ploughed for generations, and it would be sacrilegious to put a plough into them. But this remark did not apply to the inferior soils of the country, which are very numerous, and which would need proper and generous management if kept for the most part under the plough.

There prevails an impression that dairy farming can be profitably conducted only on grass land, or with only a portion of arable land, but this is for the most part a mistake arising out

of our fondness for grass land. Mr. Jenkins, of the Royal Agricultural Society, gives a valuable description of the systems of dairy farming in France, and he proves that it may be most successfully conducted where the land is all or nearly all under the plough.

The question of Ensilage is very important to dairy farmers. It is a French word applied to green fodder preserved in pits, or other places specially prepared. The pits are termed "silos." The practice is an ancient one in the east of Europe, though it has only recently come into prominence in the west. Professor Rogers, M.P., holds that this subject of ensilage is of supreme importance to dairy farmers in these islands, and it is not unlikely that he is perfectly right in saying so.

In America many farmers have given it a fair trial, and favourable results have almost everywhere been obtained. There must be some good in this ensilage question, since it has so satisfactorily answered its tests in America and in France; but, in order to make it succeed, the system must be thoroughly and carefully carried out. The Americans have an advantage over us in some respects. They can grow certain crops that will not thrive with us; as for instance, maize, which is cut while green, and stored in silos. Their climate is too hot in summer for them to successfully grow root crops; but this green maize is grown with facility, and it is peculiarly adapted for ensilage. But with us green grass will answer the purpose of ensilage, as will also green rye and oats; but vetches and cabbages are considered to contain altogether too much moisture; yet he had heard of vetches being successfully ensilaged in England, and any difficulty with regard to excessive moisture can be met by mixing oat straw or hay with the ensilage when it is packed in the silo.

The object of ensilage, is to afford green fodder for the cattle in the winter months, as nearly as possible in the same condition as the green grass of the pastures in summer. The grass, etc., is cut green, the building in which the process is carried on must be air-tight, and water-tight. The materials are well trodden down, and when the pit is full, boards are placed upon it, and

weights on the boards. A pressure of four or five cwt. to a square yard is applied, consisting of stones, or of barrels filled with sand; this excludes the atmosphere, and fermentation is checked, and the fodder is thus preserved in a state analogous to that in which it was cut in the summer time.

Dr. Voelcker, and Sir J. B. Lawes, do not go into raptures over this question of ensilage. They would have us exercise great caution in our introduction of this system. And when the opinion of agricultural authorities is not by any means unanimous on any given topic, it is generally expedient to proceed with caution.

The dairy cattle of England are in demand among all civilised nations of the world. The Jerseys, and Ayrshires, are the only British breeds which Americans characterise as real dairy cattle; the rest are regarded as beef cattle. But we regard several other of our breeds as being excellent milkers.

The subject of pedigree in connection with these various breeds has been carried to very great lengths, as in our shorthorn breed; and with dairy farmers, as the chief end of a cow is to give a copious supply of milk, the study of a pedigree of *achievements* would be of immense advantage. The American dairy farmers keep correct records of the achievements of their cows in the milk and butter department; and our countrymen would do well to follow their example in this respect. The cow in milk is more profitable than in any other capacity. For if a cow gives a large quantity of milk, say 1,000 gallons in the year (and some have even exceeded this), the weight of it is upwards of 4½ tons. Suppose this to contain 10 per cent. solids, this would give over 1,000 lbs. of solids. If the cow be fattened, she seldom, unless she is a very large one, produces 1,000 lbs. of beef, and that indeed consists of a large proportion of water, and of bone, which is not food. Besides, if we kill the cow we have finished with her, whereas we may go on milking her for years. From these figures we see that a good milking cow produces a very much larger quantity of food in the form of solids, than when employed in any other way.

An analysis of thirty-four samples of milk showed that the

average specific gravity is 1030; or in other words milk is three per cent. heavier than water. The cream volume was 13·8. The water in the milk is stated at 85·85 per cent., 4·6 per cent. was curd. The butter fats were represented by 4·62, sugar 4·82, and mineral matters ·65.

A comparison between the value of beef and milk as food, shows that one pound of milk contains 13·73 ounces of water, and the same weight of beef consists of one-half water. There are ·65 of flesh formers in the milk, and 2·4 in the same weight of beef. Fat formers in milk 1·51, and in beef 4·8. The mineral matter is ·11 in milk, and ·8 in beef. It comes to this, that 3 lbs. 7 ozs. of milk, are equal to one pound of beef in flesh formers, and 3·17 lbs. of milk to 1 lb. of beef in carbo-hydrates, or heat-producing compounds.

The cost of the milk at 5*d.* a quart, would be about 6½*d.*, but in the form of beef 1*s.* would be paid for the same amount of available materials.

Milk is a wonderfully complete fluid, and is the only known article of food which will sustain life alone. It is full of small globules, which contain the fat of which the butter is made; and they are infinitely small. They are supposed to be covered with a small delicate shell of casein. Others regard it as made up of condensed serum. In one pound of milk it has been estimated that there are 40,000 millions of these minute globules of fat.

The quality of milk varies from a variety of causes. Though the lecturer was in favour of the stringency of the Adulteration Acts, yet he allowed that it was possible for a man to be prosecuted for adulteration, when no such practice had been engaged in.

The quality will vary with the food supplied. Cows fed on the grass produced on sewage farms, and on other very succulent and forcing food, as brewers' grains, malt-coombs, and the like, will yield milk which is thin and poor in fats; but when they are fed on cake and various meals, the milk will abound in fatty matters.

The time of the year, the breed of the animal, the climate and the soil, the age of the animal, the period of calving, the changes in the temperature of the atmosphere, the degree of digestibility

of the food, and the amount of exercise taken in search of it, all cause variations in the quality of the milk. Rapid changes from heat to cold diminish the quantity, and at the same time cause a poorer fluid to be secreted.

The variations have been found to range from 83·5 to 90 per cent. in the case of water; 3 to 5 in casein; 3 to 5·5 in milk; 1·8 to 5·2 in butter, etc.

Professor Sheldon next drew attention to the consumption of milk in London. In the metropolitan district of the parishes touching on and included in the 15 miles radius from Charing Cross, the population was in round numbers 5 millions. If each person drank or otherwise swallowed a half-pint of milk a day, this would give 23 gallons a year per head, or a total of 115 million gallons per annum. This quantity at the retail price of 1/8 a gallon would cost 9,583,333*l.* The daily consumption is 312,500 gallons; and to obtain this 26,000*l.* a day is expended. Milk cannot be profitably sold for less than 5*d.* a quart, considering the difficulties now experienced by those who have to collect it and sell it to the retailers. The total metropolitan expenditure per day for dairy produce may be computed to be 45,817*l.*, which includes 6,393*l.* for cheese, and 13,383*l.* for butter, reckoned at 13 lbs. per capitum per annum of each of the two last-named articles of food, and at 8*d.* and 1/6 per lb. respectively.

It requires 261,363 cows to provide London with this quantity of milk, supposing cows give an average of 440 gallons each per annum. Reckoning the value of a cow at 20*l.*, this represents a capital of 5,227,260*l.* invested in dairy farmers' stock. The tenant farmers' capital may be set down at double this sum, or 10,454,520*l.* Suppose four acres of land to be required to maintain a cow, and to be worth 80*l.* an acre; the landlords' capital would be represented by 83,000,000*l.*, so that the landlords' capital, together with that of the tenant farmers', which is employed in providing London with milk, is 94,000,000*l.* while the total capital involved in the supply of cheese, butter, and milk is altogether something like 160,000,000*l.* Twenty-two pints of milk are reckoned to produce 1 lb. of butter, and 9 pints 1 lb. of cheese, which loses about 15 to 20 per cent. in

ripening. These calculations do not pretend to be more than approximately correct, and they have been made simply to illustrate the vast importance of dairy farming.

The accommodation on dairy farms is usually supplied by the landlord, though many tenants lay out money themselves in it. Strict cleanliness is of the utmost importance in dairies for the making of butter and cheese. The temperature must be maintained at as nearly uniform a figure as may be. A difference of eight or ten degrees often causes much mischief, as the milk is readily influenced by any change in the temperature. Milk very quickly absorbs any impure odours; thus not only should the room be of a proper temperature, but the air with which it is ventilated should be as nearly pure as possible. Milk is rich in nitrogen, and the ferments seize upon it, find congenial food in it, and lead to its early decay.

Many important improvements have been made in the utensils employed in the dairy. A model of the centrifugal cream separator was exhibited and explained. This machine enables us to obtain the cream from the milk directly the latter is got from the animal; and fresh butter may be made within one hour. It is, however, considered advisable to give the cream time to "ripen" before churning it, in order to obtain a fuller-flavoured butter.

There is a deal of art in churning butter. The Danes are probably the best butter-makers now. In the best system of butter-making, as soon as the butter begins to form, they pass the butter-milk through a sieve; pour in cold water, and thus obtain butter perfectly free from the butter-milk. In this state it will keep for a long time, for the butter is deprived of the casein and nitrogenous matter which lead to decomposition. These facts are borne in mind by the Danes, and their butters are of such excellence that they can favourably compete with us in our own markets, simply because they bestow more pains than we do. Only the purest salt should be used, and in moderate quantity, and the butter should be neatly presented to the public.

In the management of dairy stock it must be remembered

that "the milk goes in at the mouth," and good milk cannot be obtained unless good food be supplied.

In conclusion reference was made to the laws of kindness towards live stock, which cannot be fully realised by those who have not paid attention to this subject in connection with the management of cattle.

FARM CROPS,

Their Habits and Requirements.

By PROFESSOR W. FREAM, B.Sc., F.L.S., F.G.S.

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A LECTURE

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THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

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FARM CROPS,

Their Habits and Requirements.

All plants are built up of cells, and, as the cells are of microscopic size, most plants contain an enormous number of them. There are, however, some plants which consist only of one cell; so that on this one cell fall all the functions of growth and multiplication, of absorption and assimilation, which in the higher and more complex plants are performed by definite groups of cells. It may at the outset be inquired, What is a cell? The only answer we can give is, that it is a small mass of the living matter called protoplasm. It may, and usually does, possess an external covering or coat, which is called the cell-wall, and which consists of a substance named cellulose. That the cell is a living thing is proved by the fact that it can increase in size, and that by division or by some other equivalent process it can produce other cells like itself, which can also grow and repeat the operations of the parent cell. But the plant-cell is incapable of effecting any of these changes unless it be supplied with food, consisting of water, certain gases, and mineral salts in solution, all of which find their way through the porous cell-wall into the contained protoplasm, by the vital energy of which their chemical elements are worked up into plant substance. The cell-wall is formed by, and out of, the protoplasm; and, in multicellular plants, every part of the plant has at one time or another entered into the composition of the protoplasm. Hence the protoplasm itself is continually

varying; it is incessantly receiving new material from without, and simultaneously it is building up the organic substance of the plant. All attempts to determine the composition of protoplasm have failed, and it has never yet been artificially produced—in other words, the only known source of protoplasm is pre-existing protoplasm.

One of the simplest plants known is that which may be found in abundance in the brewer's vat, and which exists in myriads in what is called barm or yeast. When a little bit of yeast is spread out on a glass slide and examined under a high power of the microscope, it is seen to consist of numbers of excessively minute independent cells of a pale buff colour. The thin cell-wall enveloping the inclosed protoplasmic granules may easily be distinguished, and in some cases smaller cells may be seen budding off from the wall of a parent cell. This unicellular yeast-plant, or *Torula*, as it is called, grows in profusion in the sweet barley-wort obtained by steeping malt in water, and its growth and mutiplication are accompanied by a conversion of the saccharine solution into alcohol. It is well known that beer is produced by fermentation, in which process the change is not merely chemical, inasmuch as it can only be effected by the presence of living matter. In the process of malting, the barley which has been sufficiently raised in temperature to cause the process of germination to begin, is allowed to remain at that temperature till all, or nearly all, the starch in the grain has undergone conversion into sugar. The temperature is then raised high enough to kill the young plant, and the grain, or malt, as it is now called, is then steeped in water, and the barley-wort containing the sugar in solution is allowed to undergo fermentation. During fermentation a great deal of common alcohol is produced. I wish to draw attention to the fact, that in this production a living organism is taking an essential part.

Barm or yeast consists of a great number of similar organisms which are capable of setting up the process of fermentation. On examining yeast with the microscope we see numbers of minute cells, of more or less rounded form, and inside each of these we observe a granular semi-solid material. The outer coat is known

as the cell-wall, and is a distinct covering inclosing the granular contents. If one of these cells be placed in a solution of sugar, it will begin to exhibit changes of such a nature as we associate only with life. It will grow, that is, increase in size, and it will multiply, that is, produce other organisms like itself. We naturally associate such phænomena as these with the presence of life. This living organism is in reality a plant, and is called by botanists, *Torula;* yet it is merely a mass of granular matter surrounded by a covering of cellulose.

The internal contents of this cell consist of the substance known as protoplasm, and the covering or outer wall is manufactured by the protoplasm, and proceeds from it. *Torula* is one of the simplest plants we are acquainted with, and it is important to remember its structure, inasmuch as every plant, and indeed every animal, originates in a mass of protoplasm such as we find contained within this cell-wall.

If we try to cultivate *Torula* in a solution we find that certain solutions admit of its growth and multiplication, and we notice that every solution which allows of these changes contains some organic compound, such as tartrate of ammonium or cane sugar. If we attempt to grow *Torula* in a solution not containing some such substances, failure will usually result,—still, it can feed on such an inorganic salt as nitrate of ammonium.

Every one is familiar with the green scum which collects on the roofs of houses, and especially round rain-water cisterns. On viewing some of this under a microscope, we find it is made up of a number of minute cells, similar to those of yeast or barm, and, as before, the mass of protoplasmic matter is surrounded by a cell-wall. But there is one remarkable difference, which will not fail to attract the notice of an observer, and that is the colour of the cell. In the case of *Torula* it is of a very pale buff, or nearly colourless, but the *Protococcus*—as the organism now under consideration is termed—is of a bright green.

If we try to grow the green cell, *Protococcus*, we find it will propagate itself in such solutions as favour the growth of the *Torula;* but more than this, it will grow and multiply in those solutions in which *Torula* would die. That is, it will grow in a

solution containing nothing but inorganic compounds, such as carbonate of lime, phosphate of ammonia and others, and in these solutions the minute *Protococcus* will increase in size, and produce new plant-cells like itself.

It is capable of demonstration that while *Protococcus* is growing, an important chemical change is going on. All ordinary water contains more or less carbonic acid gas, and the *Protococcus*, during daylight, breaks up this gas, retains the carbon, and sets free the oxygen: *Torula* on the other hand is always consuming oxygen and forming carbonic acid.

Special attention must be given to the fact that *Protococcus* is green, as on this circumstance rests an important and essential feature in the life-history of the plant. The green colouring matter is simply a pigment or dye, and the absolute quantity is so infinitesimal, that if it is removed by the action of ether or alcohol, the shape and size of the protoplasm appear to be in no way affected.

The little green cell then has the power of living upon inorganic matter, and it will therefore flourish in a rain-water butt. The rain collects a certain amount of carbonic acid gas, and a little ammonia and nitric acid from the air, and upon these the plant feeds. The only essential difference between *Torula* and *Protococcus*, is the presence of green colouring matter in the latter, and its absence in the former.

It is natural to look to this green colouring matter as the cause of the difference in the mode of living. The green dye alluded to is known as chlorophyll. And a plant-cell containing it is thereby enabled to break up carbonic acid, to retain the carbon and set free the oxygen; more than that, it combines the carbon so obtained with the elements of water, and thus forms starch.

I must now explain why I have dwelt at such length on these two unicellular plants. *Torula* is a type of the great group of plants called fungi. All fungal plants are similar to *Torula*, in that they contain protoplasm, usually have cell-walls, and are destitute of chlorophyll. Many fungal plants are familiar to us, none more so than the mushrooms and the toadstools. Many of the fungal parasites which attack our grain crops—smut, ergot, rust and bunt—and also the potato-disease fungus, consist, as

do mushrooms and toadstools, of an aggregation of cells, each one of which is, during its life, similar to *Torula*.

Other plants are comparable with *Protococcus*, as, for example, the green filaments found in streams; these have their cells placed end to end, and their contained protoplasm of a green colour. Such plants are called algæ. The physiological difference between algæ and fungi consists in this, that the algæ can manufacture starch out of inorganic or mineral matters, while fungal plants being incapable of this effort are dependent directly or indirectly upon the exertions of other organisms.

I have drawn attention to these plants, *Torula* and *Protococcus*, for the reason that all our ordinary plants consist of a collection of cells, some of which are of an algal character, while others are of a fungal character. The more superficial cells of an ordinary farm-plant, for example, are green, and make their own starch; the deeper-lying cells are, as may easily be shown, colourless, and obtain the starch they require for purposes of growth from the outer green cells. Thus, if we take the wheat plant in the month of May, a section will show a series of green cells on the outside, but towards the central portion the cells are practically colourless. The same thing may be observed in any of our common weeds.

Thus we see that all our ordinary plants consist of an assemblage of two kinds of cells. Those cells not containing chlorophyll depend on those which do contain it for their nutrition. The composition and constitution of chlorophyll have excited considerable interest, and though much remains to be discovered, certain definite facts respecting it are well ascertained. In the first place it will not be developed unless light be present, though there are one or two exceptions which need not be further referred to as they do not affect our present subject. A plant may grow for some time in the dark while nutriment is supplied to it, but it will not be green, as may be observed in the white sprouts of potatoes, and every one knows that the greensward which has been covered by a plank soon becomes blanched. Another fact respecting the formation of chlorophyll involves a chemical condition, viz., that iron must be present in the plant food. Chlorophyll is physiologically important, since it is the means

whereby the plant builds up its starch out of the elements of the carbonic acid and the water supplied to it. Many plants have the power of storing up material from one season to another, and this material is chiefly and usually starch, or some of its modifications. Not that the starch is stored up directly it is formed, for as starch is insoluble, it must be converted into sugar in order that it may travel in solution through the plant, before being re-converted into starch and stored up in the appropriate part.

Let us now consider the plant in the soil. The root has particular work to do, viz., to absorb mineral substances in solution. The soil water dissolves the mineral ingredients, and this solution is indispensable, inasmuch as the plant can only take its food in a fluid form—either as a gas, or a liquid, and the liquid food thus consists of a very dilute solution of substances contained in the soil.

The mode in which oil or spirit travels up the wick of a lamp, or ink through blotting paper, furnishes an illustration of the way in which the solution travels along the cell-walls of the roots and so into the body of the plant. The plant obtains through its roots all its nitrogenous substances, but the whole of the carbon comes practically from the atmosphere, and is taken in as carbonic acid gas at the leaves. The roots thus supply the liquid food obtained from the soil, while the leaves provide the gaseous food derived from the atmosphere, every leaf having on its under-surface a vast number of minute openings, called stomates, through which the gases find their way. Thus the plant has two chief means of feeding—by the root and by the leaf; and these are the two great organs of vegetative life.

We may now take the wheat plant as a good type of a farm crop, and consider for a while how the habits of the plant have influenced its requirements, and how conversely we have been enabled from a knowledge of its requirements to modify its habits. It differs from most other crops in that it is sown in the autumn, and this custom is of great antiquity, and probably originated in a desire for a division of labour. Wheat, like all the cereals, is an annual, and there is no doubt that the first

cultivated wheat was sown in the spring. Then the interesting question arises as to how the change was effected from the spring-sown wheat to that sown in autumn. For if we take the so-called April wheat and sow it in the autumn, in all probability a very poor crop indeed would be obtained. We have a similar example in the case of vetches. There are spring vetches and winter vetches, and probably the difference in both cases has arisen simply from an effort on the part of the cultivator to habituate the plant through many generations to earlier and earlier sowing.

With wheat our object is to get in the grain before winter, and then it is left till the spring of the year, when the ground is found to be very loose indeed. This is due to the growth of the young plant, and it is a well-known fact that the mechanical force of vegetable growth is very great. Hence in the spring of the year we find the field of wheat undergoing the operations of harrowing and rolling. The harrow stirs the soil, and to some extent crumbles it, and the roller brings the soil into a firm condition. This consolidation of the soil is absolutely necessary, as the more soil we bring round the roots of a plant, the greater amount of mineral food do we supply in the same space.

If the plant be examined at this season of the year, we shall not discover the main root. The wheat belongs to a class of plants which possess the character that their main root early ceases to grow altogether, and from the aborted main root, which just comes below the grain, a number of fibrous rootlets may be seen to depend. The rootlets penetrate deeply into the earth, and hence wheat feeds on the lower strata of the soil. In the case of barley, we find the roots spreading themselves nearer the surface, consequently this plant is more a surface-feeder than wheat. So we see that through this difference in root character, wheat and barley, though they feed on the same constituents of the soil, draw their food from different portions of it. Hence in some cases wheat is taken after barley in rotation.

After the wheat plant has germinated, a period arrives when the nutriment stored in the grain will be quite used up. This is somewhat analogous to the period of weaning in mammals, and the wheat suffers a temporary check known as the weaning or

speaning brash. Now the plant, which up to this time has been nourished by the food stored in the grain, is left to its own resources. If it gets through this period, as it usually does, a change in its mode of development will be observed. A number of leaf buds are formed, the rootlets are largely increased, and at the junction of leaves and rootlets a considerable thickening takes place, constituting the "collar" or "crown," so that in this way one grain may produce many ears of wheat, while the root development becomes correspondingly dense. This is the process known as the "tillering" of wheat. It frequently happens that the more vigorous plants will get in advance of those which are less vigorous. This will be especially the case if the winter has been mild. The field of wheat then presents a very uneven appearance, and it would be highly unsatisfactory for the farmer to have the crop ripening at different periods, the object of the cultivator being to have the whole of the crop arrive at maturity at about the same time. Wheat in the condition referred to is called "proud" wheat, and in such cases it is a good plan to send sheep across it. They will eat off the plant as far as the "crown," and then the whole crop will take a fresh and uniform start and go on growing till harvest.

After the time of fertilisation, that is, after the ovules have been fertilised by the pollen from the stamens, the wheat plant takes little or no nourishment from the soil. The roots have terminated their physiological functions, and after that period the change which goes on is merely a transfer or migration of nutritive matter from the leaf and stalk into the grain.

We must bear in mind that wheat is grown almost entirely for its grain. In the production of seed the plant exercises the greatest physiological effort of which it is capable; and in our ordinary annuals and biennials this exertion kills the plant. The seed contains much nitrogenous matter stored up for the nourishment of the young plant which is to follow; and it is absolutely necessary therefore that nitrogen should take a prominent position in manures supplied to crops grown for seed.

If the grains of several kinds of wheat be examined, we shall be struck with the differences in size, in form, and in colour.

How has this difference originated? If turnip or cabbage seed be similarly examined, very little difference is discoverable. Since wheat, barley, oats, &c. are grown for grain, all our improvements have been instituted in the direction of securing a better and finer seed, and to obtain these results we have neglected the rest of the plant. Thus, after these cereals have been cultivated from time immemorial, the general appearance of the growing crops is still substantially the same until the ears of the plant be examined.

We may next consider the turnip as another type of farm plant. It is an example of the root crops. There is a great difference between the root of the turnip and that of the wheat. We found that the primary root of wheat soon ceased to grow; in the turnip the main root continues to grow, and a number of other and much smaller roots are seen to grow from the lower part of it.

The turnip has been brought to its present stage of perfection entirely through selection of seed, and by sowing such seed on suitable soil. The wild turnip is a weed, the root is almost gnarled. The turnip is a biennial, so that the plant grows from the seed in the first year and stores up nutriment in this case in the root, and, in the second year this is employed in the production of seed, after which the plant dies. The best turnips may degenerate into the wild form if left to themselves.

There is no variation more easily induced in a plant than a succulent swelling or hypertrophy of the root, and this swelling has, in the turnip, acquired a certain degree of fixity or permanence, as agriculturists have laboured with this express object in view.

There is another notable point of difference between the turnip and the wheat, and that is with respect to leaf development. In wheat the leaf is called upon to make no extraordinary exertion, but in the turnip the leaves have an enormous amount of work to do. Comparing the bulk of a turnip with that of a wheat plant, we find the wheat grain is heavier than a turnip seed. But if we take the weight of a turnip seed as $\frac{1}{25}$th of a grain, and a turnip plant as weighing six pounds, we find that the turnip is

1,050,000 times the weight of the seed from which it has been produced. The whole of this increase has been derived from the soil and from the atmosphere. Hence we see the necessity for a large leaf surface, and of extensive leaf development. The root fibrils are the active agents which absorb from the soil the nutrient moisture and pass it into the plant, where it is worked up and elaborated into the substance of the plant-body. All, or nearly all, the carbonaceous matter of the plant is obtained through the leaves.

The turnip plant occupies the soil only a short time. It is sown in a damp furrow in order that it may germinate quickly. A great deal more seed is sown than is necessary, as it would be impossible to plant it out in the manner in which cabbage is treated. One reason why it should be sown in such abundance is to provide against the ravages of the turnip-fly.

Turnips are ready for pulling about October or November, and even when they are grown for seed it is always desirable to pull and store them through the winter and then plant them out again. A good, sound, shapely bulb may then be selected, and precociousness of growth is also prevented. I saw a case lately in which cabbages had been so influenced by the mild wet winter that they were all running to top, so that seed would be produced abnormally early, and the plants were exhibiting a weakness which, unless checked, would tend, through the seed, to become perpetuated.

Turnips occupy the soil for about the same length of time as barley, though some may be left on till the spring for sheep-feeding. Barley is usually the last white crop we get in. It is sown about March, and thus it is in the soil a short period compared with wheat. Barley requires a better and finer tilled soil than any other of the cereal crops, and on account of the short time (five months) it occupies the soil, it requires its nutrient material to be supplied in a readily available form in the manures.

"The ploughs are close up to the hurdles" is a phrase that may often be noticed in the agricultural journals in February and March. This refers to the ploughing of turnip stubbles, after feeding by sheep, with a view of putting the land into barley.

The land is already highly charged with speedily available manurial ingredients, and by ploughing and cross-ploughing is obtained that fine tilth which is so essential to the growth of barley, since its roots spread out near the surface.

In classifying plants according to their habits and requirements, a great many errors may be fallen into, among which may be mentioned one that has often misled beginners, viz., that all root crops require the same treatment. Here we see the advantage of an historical knowledge of the plants we are cultivating, the use of being able to trace them back to their wild progenitors. Thus, the turnip and swede are closely similar, while the mangel differs widely from both.

The wild mangel gets salt on the muddy flats of the sea shore, and thus we are led to give salt to mangels and beets as manure. The difference in colour is only trivial, the one being red and the other yellow. The mangel is simply a field beet, while the beet-root may be regarded as a garden mangel.

Those plants between which there exists a close ancestral relationship require the same kind of food, and therefore should receive the same manures. In the class of which the turnip and swede are types we may place rape, kohl rabi, mustard, cabbage, and kale. They all have the same flavour and the same alliaceous odour, and they all sprang from the same common progenitor. Yet how different they are in their habits! The mode of obtaining the food may be very varied, though the food requirements are practically the same. The plants mentioned are known as the cruciferous crops.

Take another great class known as the pulses. These crops grow most readily on limestone soils. As in this country most soils contain lime, special preparations are not necessary, but where it is deficient gypsum is added as a source of lime. If we trace these plants to their native habitats, it will be found that they abound on the chalk downs and oolite. We may include under this head peas, beans, clovers, medick, lucerne, sainfoin, and vetches, and they all have the same general manurial requirements. The clovers are a well-defined crop. Peas and beans are grown for their seed, but clovers, sainfoin, lucerne, and vetches are note-

worthy as possessing great leaf development, and in a classification for agricultural purposes they would be placed among leaf crops. We cannot always bring their seed to perfection in this country, as our climate is too moist, hence much of our leguminous seed, notably sainfoin, is imported from France and elsewhere. Lucerne is an interesting plant and deserves more attention in this country than it at present receives. Being very deep-rooted it is able to resist drought, hence it is grown largely in India.

The parsnip and carrot though they are root crops, are yet classed by themselves as to manurial requirements. They receive the same food, and have the same general structure, but they have few characters in common with the turnip or the mangel.

The other important classes are the cereals and the grasses. They have the same kind of root development, and the manure used should, generally speaking, be the same with both classes of crops. There are the same adventitious roots, in some cases spreading out near the surface and in others extending greatly downwards, the same habits of growth, and the same limited leaf development. But the object of their growth is entirely different. In the one it is to obtain seed, while in the other this tendency is checked.

The habits of grasses vary much among themselves. Where we grow a crop of wheat or turnips, we obtain a crop of the same character throughout, and the struggle is between plants of the same kind; but in the case of pasture grasses we have a struggle for existence amongst many different species, still but little controlled by man. Some grasses penetrate deeply into the soil, while in others the reverse takes place. Some have abundant leaf development, and cover the smaller grasses and choke them. Some have leaves half an inch broad, in others the leaf is a mere bristle. Some respond best to one kind of manure, others derive most advantage from another. Some have creeping underground stems which insinuate themselves amongst the roots of other grasses. Some ripen their seed so early in summer that there is an undue advantage over the others, and many other points would be worth attention did time permit. There has been much controversy as to when a field of meadow grass should be

mown, but in our unhappy climate the weather appears to be the sole arbiter.

At the close of the lecture Professor Fream suggested to teachers the advisability of adopting practical illustrations, as for example, sowing some seeds in moist cotton wool, and carefully watching the process of germination and growth. He said that more would be learnt by the pupils from observations such as these, than from a long lecture without them.

The Professor also remarked upon the great amount of work which still remained to be done in connection with our knowledge of farm crops, as so little comparatively is known about them. Farmers have to a great extent been indifferent to this subject; so long as they obtained good results they did not take very particular notice of the manner in which such results were got. It was, in conclusion, pointed out how a general system of note-taking on the farm would be of great benefit to agriculturists.

ON SOME OF THE CHANGES WHICH NITROGENOUS MATTER UNDERGOES WITHIN THE SOIL.

By R. WARINGTON, Esq., F.C.S.

A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

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ON SOME OF THE CHANGES WHICH NITROGENOUS MATTER UNDERGOES WITHIN THE SOIL.

[ABBREVIATED REPORT.][1]

THE soil beneath our feet has been universally regarded as in some mysterious sense the mother of us all. To us, in the present day, the manner in which soil supports the life of plants and animals is still mysterious, in the sense that we are yet in the dark as to the nature of many of the substances contained in the soil, of the changes which they undergo, and of the part which they take in plant nutrition. This is especially true with regard to the organic matters, consisting of carbon, nitrogen, hydrogen, and oxygen, which the soil contains. We may, I think, usefully spend an hour this evening in attempting to sketch the general history and course of change of this organic matter, though in so doing we may often have to speak rather of our ignorance than of our knowledge. I will ask you to fix your attention at present chiefly upon one constituent of this organic matter—its nitrogen, as this is the aspect of the question which has most agricultural importance. Our subject, then, is the nitrogenous organic matter of the soil: Whence comes it? What becomes of it?

In order to start with definite notions on the subject, let us take as an example an ordinary arable field, of clay soil, in fair agricultural condition. Such a field, when all stubble and roots have been removed, will contain in the first 9 inches of the surface soil a quantity of organic matter containing about 3,000 lbs.

[1] This Report has been abbreviated from the full and complete Report published by Messrs. Harrison and Sons, London.

of nitrogen, and 30,000 lbs. of carbon per acre. This nitrogenous organic matter of the soil has been derived either entirely from the decay of the vegetable matter left in the land by preceding generations of plants, or possibly, to some extent, from past applications of farmyard or of other organic manure. It is very important to bear always in mind that the nitrogenous capital of a soil, which represents to a considerable extent its agricultural condition, depends as a rule on the bulk and composition of the previous crop residues, and on the extent to which these have been subsequently destroyed by operations which we shall presently have to notice. The present fertility of the soil is thus, in great measure, a consequence of its past fertility.

It is quite true that besides the residues of crops soils receive certain amounts of nitrogen from the atmosphere in the form of ammonia and nitric acid; but the quantity of these substances contributed annually by rain is apparently not more than 3 to 4 lbs. of nitrogen per acre; and though the amount of ammonia directly absorbed by the soil from the atmosphere may in some soils be much larger than this, the total nitrogen thus acquired, though most important as tending to counterbalance the losses of nitrogen which the soil annually suffers, will have little effect on the present fertility in comparison with the large accumulations of nitrogenous matter resulting from previous crop residues.

The nitrogenous organic matter of the soil has its origin in the various vegetable substances left in the soil as residues from preceding crops, to which in some cases we must add the residues from dressings of organic manures. A recognition of this fact is of vital importance if we are to have accurate notions as to the influence of different crops in maintaining or exhausting the fertility of the land. It is evidently the crop which leaves behind the largest amount of roots, stubble, and leaves, which will best maintain or increase the nitrogenous capital of the soil; while the crop leaving the smallest residue in the soil will be most exhausting in its effect. Permanent grass and clovers will thus stand at the head of the list as conservers of soil nitrogen; while root crops carted from the land will be placed at the opposite end of the scale.

We may now ask—What becomes of the organic matter in the soil? What course of change does it undergo?

Before saying anything as to the stages of this course of change, or about the means whereby the transformations are effected, it will be well to state at once that the organic matter in a fertile soil is continually undergoing oxidation by various agents, the general result being its conversion into three simple substances—water, carbonic acid, and nitric acid. The vegetable residues left by crops are thus reconverted into plant-food, and made fit to support the life of a new generation of plants.

That carbonic acid gas is formed in large quantities in soil has been abundantly proved by Boussingault and Léwy, and by a number of more recent experimenters. The quantity of carbonic acid produced is greater according to the richness of the soil in vegetable matter, and is much increased when farmyard manure has been applied. The carbonic acid is formed in largest quantity in summer time; the amount is also generally much increased by applications of chalk or lime.

That nitrates are produced in soil has been known from very early times. Many examples of the quantities of nitrates existing in agricultural soils of various history are given in the tables illustrating this lecture. The facts connected with this part of the subject are, however, of so much practical importance that they will be best considered by themselves after the general sketch of the course of change of the organic matter has been completed.

The first stage in the oxidation of a crop residue is marked by a rapid disappearance of carbon, doubtless evolved as carbonic acid, the nitrogen apparently remaining still in organic combination. The mean proportion of nitrogen to carbon in seven analyses is about 1 : 19, the extremes being 1 : 15 and 1 : 23. We are thus fairly well acquainted with the ratio of nitrogen to carbon in the crop residues and manure, from which the organic matter of soil is derived. If we now compare these ratios with the ratio shown by the organic matter of the soil, the disappearance of carbon becomes very striking. In the first 9 inches of the old pasture land at Rothamsted, with roots as far as possible removed, the ratio of nitrogen to carbon is about 1 : 13, while in the same

depth of arable soil the ratio is about 1 : 10, and does not reach 1 : 12 even where 14 tons of farmyard manure per acre have been annually applied for more than thirty years.

What is the true chemical nature of the nitrogenous organic matter forming the so-called humus of soils we do not know, nor even if it consists mainly of one substance, or of a variety of more and less nitrogenous bodies. The relation of nitrogen to carbon observed in the clay subsoils, and in the organic matter held in solution by the drainage waters from the experimental fields at Rothamsted, seems, however, to point to the formation of some highly nitrogenous organic matter, capable of diffusion into the subsoil.

We may now pass to a further stage of the subject, and consider the agents by which the oxidation of organic matter in soil is effected. Our knowledge on this branch of the subject has certainly made great strides in recent years. At the time when Liebig's writings directed so much attention to the subject of agriculture, it was assumed that the oxidation of organic matter took place by mere contact with the oxygen of the air. The active oxidation taking place in soil was referred to the fact that soil is a porous substance; it was assumed that the oxygen of the air became condensed within these pores, and was hence capable of exerting an increased power. We now know that the oxidation of organic matter generally requires something more than the presence of oxygen. Oxidation in nature is, in fact, nearly always performed by living agents, either by colourless plant cells, or by means of animal organisms. Our view of the nature of fertile soil has also enlarged, and instead of regarding it simply as a porous mass of clay, sand, and humus, we now look on it as a medium full of life. The soil beneath our feet is in fact not dead, but thickly peopled with a variety of organisms, with the particular functions of which we are only gradually becoming acquainted. As to whether any oxidation takes place in soil without the intervention of life, we can hardly perhaps state quite definitely at present, but it seems probable that this is the case. We cannot at present deny that some of the carbonaceous ingredients of soil may be capable of some measure of simple oxidation; but it is

apparently through the action of living agents that the oxidation of organic matter is chiefly brought about.

We will first glance at the functions of the animal life existing in soils—the worms, the larvæ, the insects. If any one will turn up a turf in a pasture field in April or May, and pull it carefully to pieces, he will probably be astonished at the amount of animal life which it contains. These animal organisms feed both on the fresh and decaying vegetable matter present in the soil. Worms, according to Darwin, may even, apparently, feed on humus. In the animal body, as is well known, carbon is speedily oxidised, carbonic acid being exhaled in the respiratory process; at the same time nitrogenous matter is returned to the soil in the form of excrement, and also in the body of the animal at death. The function of the animal is thus to burn carbon, and to cause the organic matter of the soil to become more nitrogenous.

A perfectly similar function is exerted by the fungi which inhabit soils. These feed on the organic matter present, exhale carbonic acid, and at their death contribute to the soil their own highly nitrogenous tissue. The action of fungi on soils is excellently illustrated by the fairy rings common in many pastures. Here a ring of fungus is closely followed by a ring of luxuriant grass. The fungus has fed on the nitrogenous organic matter of the soil, which is useless as food to the grass, and on the death of the fungus the nitrogen which it has taken up is left in the soil in the form of albuminoids and other bodies easily converted into nitric acid. The nitrates thus produced act as a powerful manure to the grass. The composition of the soil in the various parts of a fairy ring has been ascertained in the case of several rings at Rothamsted (*Trans. Chem. Soc.*, 1883, 208). The amount of carbon destroyed during the progress of the ring of fungus is very considerable. The difference between the amounts of carbon found in the soil outside the ring, where the fungus has not yet appeared, and within the ring, where the action of the fungus is completed, represents indeed a loss of something like 8,000 lbs. of carbon per acre.

Neither the animal life of the soil, nor the fungi, carry their oxidation of nitrogenous matter to such a point that ammonia or

nitric acid is produced. These two agents perform some of the rough work of oxidation, but do not bring the nitrogen into the condition most suitable for plant-food. This object is accomplished by the bacteria, the third of the principal oxidising agents within the soil. The bacteria of soil have been as yet but slightly studied; but such organisms undoubtedly exist in great numbers, and of many kinds and functions.

It may be taken as a general rule, that in the absence of oxygen bacteria act as ferments, splitting up the organic matter into new compounds; while in the presence of oxygen they become active oxidising agents. In the case of many bacteria the nitrogen of the organic matter attacked is reduced to the form of ammonia, and under some conditions it may be partially evolved as free nitrogen. The nitrifying organism forms apparently a class by itself, it alone producing nitric acid. We do not yet know with certainty what nitrogenous bodies are capable of direct conversion into nitric acid. Albuminoids, amides (asparagine and urea), and ammonia can indeed readily be nitrified, but the first stage of the action on albuminoids and amides is apparently the production of ammonia, and we cannot yet say if the action of the special nitrifying organism begins at the ammonia or extends to the earlier stages of the action. If ammonia alone is attacked by the nitrifying organism, we must then regard the other associated bacteria as executing the preliminary portion of the work.

We will now glance at the influence which external conditions exert on the action of the various agents just mentioned. One essential condition for processes of oxidation is of course the presence of oxygen: an open, porous soil is thus far more exposed to oxidation than one in a closely consolidated condition; the effect of tillage is consequently greatly to promote oxidation. Water is also essential for the activity of all living agents: oxidation is thus far more rapid in a moist soil than in a dry one. A great excess of water is, however, fatal to oxidation, air being naturally excluded as soon as the soil is filled with water. Temperature is another prime factor in determining the rate of oxidation in soil; the activity of all living agents, whether

vegetable or animal, being dependent on the occurrence of a favourable degree of heat, and being confined to certain specific ranges of temperature. Oxidation is consequently far more rapid in summer than in winter, and much more energetic in hot climates than in cold. A further condition very favourable to oxidation is the presence of some base in the soil, capable of neutralising the acids that are produced. Without the presence of such a base no formation of nitric acid will occur. This part is generally played by the carbonate of calcium commonly present in soils. Liming, of course, will act in the same direction.

We are now probably in a position to understand what is the cause of the enormous differences between different soils, as to the quantity of organic matter and of nitrogen which they contain.

In a peat bog we find the conditions most favourable for the accumulation of organic matter. The sphagnum and other bog plants cover the bog with a perennial growth, which supplies annually a large residue of dead vegetable matter; while the soil being water-logged, and necessarily free from carbonate of calcium, the oxidation of this vegetable residue is reduced to a minimum. Peat bogs also usually occur in cool climates.

In fertile meadow land we have conditions much more favourable to oxidation. The soil here is not water-logged, but fairly well aërated, and oxidising agents, both animal and vegetable, are abundantly present. The land being, however, always covered by a thick vegetable growth, considerable accumulations of organic matter may take place in the soil, though never to the extent observed in a peat bog.

When we next turn to arable land, we find that the conditions have become so favourable to oxidation that loss rather than gain of soil nitrogen is probably the general rule. Oxidation is here greatly assisted by the operations of tillage, and by the fact that the land lies in a state of fallow during a considerable part of most years. In such soils large quantities of nitric acid are produced, which may be washed out by winter rains and lost. At Rothamsted the old pasture land contains in the first 9 inches

nearly twice as much nitrogen and more than twice as much carbon as the arable land to the same depth. As all arable land was once pasture or woodland, the loss that has occurred during cultivation is obvious.

It is quite clear from what has now been stated, that arable culture affords great opportunities for serious loss of soil nitrogen, and from this point of view arable culture may be said to present considerable disadvantages as compared with pasture; but there is another side to the question. The rapid oxidation of organic matter which occurs under tillage means the production of a large amount of available plant-food. The nitrates produced, though liable to be lost by drainage, are also equally capable of producing valuable crops, and the skill of the farmer is displayed in so arranging his methods of culture that the nitrates shall be a source of profit instead of loss. The effect of free oxidation on the productiveness of land is, indeed, strikingly shown by the fact that arable land, though containing only half the amount of nitrogen that is found in pasture, is, nevertheless, capable of yielding a greater weight of annual produce per acre.

SOUTHDOWN SHEEP:

Their History, Breeding, and Management.

By HENRY WOODS, Esq.
Merton, Norfolk.

A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

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SOUTHDOWN SHEEP:

Their History, Breeding, and Management.

[ABRIDGED REPORT.][1]

IN the Course of Lectures now being delivered under the authority of the Institute of Agriculture, for the promotion of agricultural education, the breeding and management of sheep naturally finds a place, and I have been invited to speak upon that part of the subject which relates to the important breed of Southdowns.

The Southdown breed of sheep is believed to be indigenous to the Downs of Sussex. It is said by the editor of *The Farmers' Dictionary* to have existed there before the Conquest. It is, no doubt, one of the purest and most unmixed breeds in Britain. Little seems to have been known about Southdown sheep outside the comparatively limited area in which they were kept until about two hundred years ago, when (as Mr. Thomas Ellman writes) several flocks on the South Downs appear to have been nearly annihilated by an outbreak of small-pox, which was imported into this country from Holland about that time.

The sheep which the disease spared attracted rather more notice than had previously been bestowed on the breed, but it was not until the latter part of the last century that they came to be much esteemed. It was, in fact, Mr. Arthur Young, who in one of those useful essays published about 1794, which made his name famous in the agricultural world, first called public attention to Southdown sheep, speaking favourably of their hardy constitution, and of the fine quality and flavour of the mutton they produced.

[1] This abridged Report has been taken from the full and complete Report published by Messrs. Hamilton, Adams, & Co., London.

About the same time they were also described by other writers as being speckle-faced, long and thin in the neck, high on the top of the shoulders, slack in the girth, high and narrow on the loin, low at the rump end with tail set on very low, sharp on the back, flat-ribbed, narrow in the forequarters, and generally, though with little space between their forelegs, showing a fairly good leg of mutton. As a rule they were looked upon as plainly-formed, if not ugly, sheep, which produced good and fine-flavoured flesh. They were small, *very small*, as compared with the Southdowns of the present day.

To Mr. John Ellman, of Glynde (the father of the late Mr. John Ellman, of Landport, and Mr. Thomas Ellman, late of Beddingham), will always and most deservedly belong the credit, not only of bringing Southdown sheep into more general notice, but of commencing (about the year 1780) a course of valuable, well-considered, skilful, and successful experiments upon them. These experiments were conducted by him with slow and steady good effect during the long period of more than half a century.

Notwithstanding the great improvement which Mr. Ellman effected in the breed, it was some time before Southdown sheep won their way into public favour, if we may judge of this by the prices which they made. But we must bear in mind that in those days sheep, even of the most esteemed breeds, did not realise high prices. It appears, however, from an article in the *Agricultural Annual* of that date, that in 1836 there was a considerable increase in the value of Southdown sheep, the breed having become better known, and its merits then more fully recognised. In the year 1787 a Southdown ram fetched for the first time as much as ten guineas, Mr. Ellman selling two for 21*l.* to Lord Waldegrave, of Essex. In 1790 Mr. Crowe, also of Norfolk, bought of Mr. Ellman forty ewes at 26*s.* each, and a ram at twelve guineas.

From this year I believe we may date the increased introduction of Southdown sheep into Norfolk, under the auspices of that renowned encourager of agricultural improvement and progress, Thomas William Coke (afterwards Earl of Leicester). Mr. Ellman certainly visited Holkham in the year 1790. Having seen the

Norfolk breed of sheep, which he considered more remarkable for their activity than anything else, he suggested to Mr. Coke the desirability of a trial of a few Southdown ewes to see how far they would be suited to the soil and climate of Holkham. Mr. Coke assented. As his own sheep were sold, Mr. Ellman bought 500 ewes and lambs from the best flocks in Sussex, and sent them to Holkham, with four rams from his own flock; Mr. Coke giving as much as seventy guineas for these rams. After this, Francis, Duke of Bedford, the Duke of Norfolk, and other noblemen and gentlemen, visited Glynde, and were the means of introducing Southdown sheep into different counties. The first ram that ever fetched fifty guineas was sold by Mr. Ellman in 1796 to Mr. Goodenough, of Dorsetshire. From that time, for many years, there was a steady demand for all the rams Mr. Ellman could supply at prices ranging from twenty to 100 guineas each for the season. In 1800 Mr. Ellman disposed of 200 ewes to the Duke of Bedford for 500 guineas, and in 1802-3 his Grace paid him 300 guineas for the use of a ram for the two seasons, which was the highest letting price ever made by a Glynde ram. The price at which Mr. Ellman sold his draught ewes soon rose to three guineas each, and afterwards to four guineas, at which price he contracted for the sale of the whole draft to one person (Mr. George Talbot, of Gloucestershire) for four years.

The next person who did much to improve and popularise the Southdown breed of sheep was the late Mr. Jonas Webb, of Babraham, in Cambridgeshire. This eminent sheep-breeder well deserved the respect in which he was held throughout his life. He was a true representative man, of whom his country might well be proud. His name will be remembered for ages to come, and he will be spoken of as one of England's most distinguished breeders and improvers of Southdown sheep. Great was his success as a farmer, and no wonder, for he carried out what he undertook with vigour and thoroughness. His connection with Southdown sheep commenced when he was a young man. He entered upon a series of experimental trials with several different breeds of sheep in order to find out which breed was most suited to the Cambridgeshire uplands. At that time Mr. Webb had no

particular preference for any one breed, but after exhaustive trials he fully satisfied himself that Southdown sheep produced the greatest weight, and gave the best quality of mutton for the amount of food consumed, and were consequently the most profitable both to breeder and grazier.

These trials determined Mr. Webb to have nothing to do with any other breed of sheep than Southdown. He therefore purchased for the Church Farm, at Babraham, ewes and rams of the late Mr. John Ellman, of Glynde, and other breeders in Sussex. Having started it, he gave unremitting attention to his flock, and soon witnessed a gradual but sure improvement in its character.

Many will remember the Babraham ram lettings, and the annual dinner which followed, with mingled feelings of pleasure and regret: pleasure in thinking over those days, and regret that such meetings are now things of the past. Who can forget the long and gaily-decked waggon-lodge which formed a characteristic banqueting-hall filled with agriculturists, and amongst them many leading noblemen and gentlemen, who came not so much to do business as to pay honour to an old friend! who does not remember the late Earl of Hardwicke, with his burly John Bull form and manner, seated at the head of the guests delivering his short and pithy speeches, replete with humour and happy hits on current topics! who does not recall the jolly, cheerful, Sam Jonas, acting as master of the ceremonies, and his face giving off radiance enough to have lighted up the place without the aid of candles; or the lithe and active John Clayden, who was here, there, and everywhere, with a kind word for everybody; or the host himself in his seat at the bottom table, supported by his friend and opponent in Southdown breeding, William Rigden, and by the tall and spare form of Jem Turner, of Chyngton, one of the best judges of Southdown sheep that ever lived! Those were indeed meetings the like of which will never be seen again.

In 1855 a two-year-old ram was let for the season for 170 guineas, and in 1860 a yearling was sold, after being used at Babraham, for 250 guineas. These were, I believe, the highest prices made by Babraham rams. As might be expected, Mr.

Webb was a most successful exhibitor of Southdown sheep at the Royal and other Agricultural Shows. He continued to exhibit with marked success at most of the Royal Shows down to and including the Canterbury meeting in 1860, when he made a clean sweep of the prizes for rams. In 1861 the Babraham ewes and rams were sold by auction, and the entire flock fetched the large sum of 16,646*l.* Surviving but a few months the dispersion of his favourite flock, the owner passed away in November of the same year. Such is the history of the Glynde and Babraham Southdown flocks.

Here I would venture to remark that while the owners of the flocks of which I have just spoken were scrupulously careful to maintain the purity of the breed, each aimed at a different type of animal. "*Small* and good" sheep were clearly Mr. Ellman's aim; Mr. Webb's, "*large* and good." Believing that large sheep were much the best and would be the sheep of the future, I need not say how well Mr. Webb succeeded in producing animals of larger frame and greater weight than the Southdowns of Mr. Ellman's day; while, at the same time, retaining the true type and all the essential points of a pure-bred Southdown sheep. It is, of course, a recognised fact (or ought to be by every careful breeder of Southdown sheep) that the first and greatest point is to maintain extreme purity; to allow no cross to diminish the inestimable value of purity of blood. The direction in which improvement in Southdown sheep is desirable is uniformity of character, strength of constitution, excellence of wool, development of symmetrical form, mutton-producing properties, smallness of bone as compared with weight of meat, yet not such smallness as to prevent the carrying of an increased amount of flesh.

I may say that these are the points to which our attention has been always most especially directed in the flock of which I have now had the management for upwards of thirty-six years. It is not for me to say how far we have been successful; indeed, I must ask you to excuse me, if, in illustration of my subject, I am in some degree compelled to refer to the Merton flock. I shall do so very briefly, and only when it enables me to trace more clearly the history of progress and improvement than could be

done by reference to other flocks with which I am less intimately acquainted.

Following the subject of increase in weight I find myself obliged to mention the three Shearling Champion Prize Merton wethers of 1870, which averaged a little over 242 lbs. each, live weight. This I believe to have been the greatest weight recorded up to that time. Some persons, indeed, at the Exhibition, thought that the great weight of those sheep suggested that there had been some cross in the breeding. I need scarcely say how utterly groundless was any such suggestion. The same imputation had been before laid to the charge of Jonas Webb. When he succeeded in producing large Southdown sheep of true type, and with as much quality as the small sheep of former times, he, too, was suspected of having had recourse to a cross with some other breed, but the suspicion was as unfounded in his case as in ours.

Since the Smithfield Show of 1870, other Merton pens of shearling wethers have been exhibited of nearly the average weight of the Champion sheep of that year, and no question as to the purity of their breeding was ever so much as hinted at. At the late Smithfield Exhibition, Lord Walsingham's prize pen reached the unprecedented average for Southdown wethers of 251 lbs. This showed an increased weight of 9 lbs. per sheep over the weight of the Champion wethers of 1870, to which I just now referred, and of 26 lbs. as compared with the weight of the Champion wethers in 1882. I have no intention of trying to make it appear that with the Merton flock more has been accomplished than may be done by other flocks, or of keeping from you those particulars of management to which is due that largeness of frame and excellence of mutton without the infusion of any blood but that of the purest Southdown, to which the Merton sheep have attained. There are, of course, many excellent pure-bred flocks of Southdown sheep in this country whose history, peculiarities, and merits I am obliged, through stress of time, to pass over. But standing in the front rank of successful Southdown breeders at the present day we are naturally reminded of the Prince of Wales, the Duke of Richmond, the Earl of Suffolk,

Lord Alington, Sir William Throckmorton, Bart., F. M. Jonas, George Jonas, and last, though by no means least, my excellent friend Henry Webb.

In the formation of a flock of Southdown, or any other breed of ewes, great care and judgment are, of course, most essential. Uniformity of character, so that the ewes look as much alike "as peas in a peck," should be your first object. If you desire to judge of the general character of a flock of Southdown ewes, and to see if they have, as it were, a family likeness, have them driven a short distance from where you stand, and then suddenly wheeled round so that their heads are thrown up and their faces seen at a glance. This will enable you to detect any marked want of uniformity, if there be any. In a word the ewes should be "matching" to the eye. When drawing ewes, and separating them into lots for the rams, you must exercise great judgment in the selection, carefully noting individual *formation and peculiarities*, so that the ewes in each lot are as much alike as possible, and adapted to the style of the ram you intend to put to them.

There is no flock so perfect but some defects will be found in the ewes, which require correcting, and, therefore, care should be taken to use a ram which will be likely to improve in the offspring the faulty points observable in the ewes. It must, moreover, be a matter to which the flockmaster gives anxious attention in selecting a ram, that in correcting defects in the ewes he does not overlook any faulty points in the ram which may be transmitted through the ewe, and thereby create imperfections in the lamb which the mother did not possess.

Only by practice and carefully observing the true principles of breeding is the flockmaster able to make a proper and judicious selection of rams and ewes, so as fitly to mate them. I therefore desire to impress upon you, agricultural students, the absolute necessity of your becoming *thoroughly* and *practically* acquainted with the good and bad points of sheep, no matter what their breed, remembering that the same care and skilful judgment requisite for the successful management of Southdowns are also required in the management of other flocks. Each breed has its own marked peculiarities, faults, and merits, which must be well

studied and carefully looked after, or a man will never become a good and successful sheep-breeder.

Remember that the breeding of good or bad animals is *no game of chance.* You might as well expect to breed a superior shorthorn beast by using an Alderney bull on a first-class shorthorn cow, as to breed a really good Southdown sheep by using an *inferior* ram on a good Southdown ewe. If a man desire, and most flock-masters do desire, to breed good and shapely sheep, no matter what their breed may be, he must first endeavour to deserve success by going the right way to work to obtain it. *Leave nothing to chance.* Many persons when they have hired a good ram try to get as much out of him as possible, and give him as many ewes as he can be got over. Now I look upon this as an unwise thing to do. Nature has its limits; and it is far more judicious to limit the number of ewes put to a ram to from fifty to seventy.

I feel that I can best explain my views and recommendations if I allow myself once more to say a few words with respect to the system of management adopted in the Merton flock. In doing so, I desire it to be clearly understood that though I have been connected for so many years with Southdown sheep, and though I may be said to regard them with all the admiration felt for one's "first love," I am by no means disposed to praise them by depreciating other breeds. A long experience has taught me to recognise the fact that while Southdown sheep are well adapted to upland and dry soils, they are at the same time wholly unsuited to some other soils and conditions. And when pointing out to you the great improvement that has taken place in the breeding of Southdown sheep during the present century, I am not unmindful of the marked change effected in other breeds, such as the Cotswolds, the Lincolns, the Oxfords, the Shropshires, and the Hampshires; and were it not for the invidiousness it would involve, I should like to stray from the immediate subject of my lecture to remind you of the honour which attaches to the names of many breeders of these sheep, who have earned the thanks of both meat-producers and meat-consumers, but time will not permit this digression.

The Merton flock comprises twelve different families, and the

shepherds know, from long experience, how to select the ewes for each family, which ram to put to them, and the kind of lambs that are likely to be produced. By this careful plan of managing the several families we have produced and maintained the large size of the Merton sheep. We have always remarked that when rams have been hired for use at Merton they have only in three instances given us a first-prize animal, but that the second and third generations, after an intermingling of fresh blood with our own sheep, have been most successful.

During pregnancy great care must be exercised not only in supplying the ewes with nutritious, health-giving food, but in keeping them from any great excitement, such, for instance, as might be produced by fright from being run by a reckless dog. I may here observe that, while fully recognising the usefulness of a well-trained sheep-dog, I cannot but protest against the way in which I have frequently seen in-lamb ewes and other sheep chased, harassed, and alarmed by a wretch of a dog, apparently under the slight control of a careless and lazy shepherd, who, to save his own legs, will unnecessarily run the dog after the sheep, heedless of the ill-effects it may produce. A good and careful man will not dream of doing such a thing. Many persons are little aware of the injury that is done by the injudicious use of dogs. If they are in-lamb ewes, there is great risk of producing abortion, and if they are fatting-sheep, the effect of the alarm caused by an excitable dog upon them is to take a good deal more off in five minutes than you can put on again in five hours. In both cases the owner is a sufferer. The excitement caused by the action of the dog does away for a time with the quietude which is so desirable for fatting animals, and consequently they do not gain flesh so quickly as they would if they were kept free from unnecessary and preventable alarm.

The question, what is the best course of feeding for in-lamb ewes, is a most important one, and calls for the greatest consideration and care on the part of the flockmaster. There exists no reasonable doubt that where ewes are kept on grass land until after they have lambed there is little fear of abortion, always presupposing that they are kept free from injury, are not jumped

over ditches and water-courses, not over-driven, nor subjected to fright, &c. I have proved beyond question, with the Merton ewes, that keeping them entirely away from turnips until after they have lambed is a decided safeguard against abortion. Up to the year 1853 the Merton ewes were folded on turnips from the end of October until the spring of the following year. They were then as unhealthy as any ewes in the country. In the early part of 1854 there were something like 110 cases of abortion, and eighty ewes died. Feeling that a change in the treatment must be made, I determined that in future the ewes should not be fed on turnips (except for five or six weeks when the rams were with them) until after they had lambed. Since that time they have been folded and fed on grass land, with the supply of grass daily supplemented by a reasonable allowance of a mixture of hay chaff and fresh-made broad bran, at the rate of four bushels of chaff to one of bran. At about the fifteenth week of gestation half a bushel more bran is added to each four bushels of chaff, and this allowance of mixed food is gradually increased in proportion to the increasing demand made by the unborn lamb on the system and strength of the ewe. Since the introduction of this change in our system of feeding the in-lamb ewes at Merton, cases of abortion have been unknown, and the mortality amongst the ewes has been at a minimum.

On this point I may be permitted to call your attention to my lecture on "Abortion and Mortality amongst Ewes," delivered in 1877. To enable me to arrive at something like a definite idea as to the cause of the fearfully large number of ewes which aborted and died in many parts of the country in the early part of the year I have referred to, I sent out more than four hundred circular letters of inquiry, each letter containing twenty questions, to flockmasters and others throughout the United Kingdom. These letters were almost all replied to and the questions fully answered. They showed clearly and conclusively that the greater part of the abortions and deaths occurred in flocks where the ewes had been fed on a comparatively unstinted allowance of common turnips and swedes unmixed with dry food; and that a good allowance of dry food undoubtedly does away with many of

the ill effects produced by simple root diet. It was also very clearly shown that where the ewes were grass-fed there was an entire absence of any serious amount of abortion and mortality.

The particulars, with the reasons given for the conclusions at which I arrived, were fully detailed in the lecture to which I have alluded. I may, therefore, especially as our time is so limited, be excused from entering further into this subject. Let me, however, add that I have every hope, when the ensilaging of green crops comes to be fully understood and appreciated as it deserves, the system will be far more generally adopted, with as much benefit and advantage to flockmasters as to dairy farmers, cheese-makers and stock-keepers in general. I am justified in this confident statement by my recent experience of the good results which have followed the use of ensilage in the case of in-lamb ewes.

As the time draws near for ewes to lamb, a sheltered, well-littered yard should be provided. This should be surrounded by straw-thatched sheds, so divided as to have a nice comfortable pen for each ewe when she lambs. These yards may be constructed for a comparatively small expenditure, and the cost will be amply compensated by the saving of life both among ewes and lambs: many that would otherwise probably be lost in severe weather being preserved by means of this timely protection. Suitable food and dry litter should also be provided close at hand, so that the shepherd has not to run about in search of these necessaries at a time when the ewes are calling for all the attention which he can give them.

Bear in mind that the duties of a shepherd at lambing time are varied, trying, and anxious, and it is a "penny wise" practice to stint him. To deny him a fair and reasonable amount of manual help when he requires it will be hard upon him, and may be the cause of the death of many lambs; because, however willing he is, there is a limit to the shepherd's bodily power, besides which he cannot be in two or three places at the same time. A careful, painstaking shepherd, of the greatest value at any time, becomes doubly valuable at the laborious and anxious time of lambing. How considerable is the importance and worth of such a shepherd can only be fully understood and appreciated by those

who, like myself, have watched his constant zeal and anxiety in endeavouring to do the best in his power for the interest of his employer.

I repeat what I said on a former occasion, that it is very desirable for the master to visit his shepherd at the lambing-fold during the night as well as during the day, as frequently as possible, and especially in coarse weather, and if he occasionally takes with him something "warm and comforting" it will be gratefully received and fully appreciated. The more trustworthy the shepherd, the better pleased he is to find the master taking an interest in his work. If everything is going on satisfactorily, it will afford him pleasure to make it known to his employer, while, on the other hand, if he is experiencing more than ordinary anxiety and difficulty in performing his duties, he will be very thankful for the advice and assistance that his master will be able to give him—more especially in cases where the shepherd has reason to put confidence in the skill and knowledge of the master. You therefore see how very necessary it is for you, agricultural students, to be well *grounded* in all the practical details of sheep management if you would become successful flockmasters, or desire to have your shepherds look up to you for advice.

In a lecture on the "Diseases of Sheep," delivered in November, 1872, I referred to most of the diseases to which sheep are liable. On this occasion I can refer to one or two only. There is that fatal disorder "Straining in Ewes after Lambing," as to which I may say that in the spring of 1878, I made known the success which had followed the treatment of ewes when affected with this disease by the use of carbolised oils, by which an enormous amount of suffering and loss amongst ewes is prevented. Not only did the Merton shepherd save every one of the ewes thus afflicted when first we adopted this treatment, but the flock in the last few years has been entirely free from the disease, which I think is wholly attributable to the free application of the carbolised oils whenever a case of difficult lambing has arisen. Since this treatment was made known by me through the agricultural papers, it has been tried by many flockmasters, and with almost unvarying success. One of the leading physicians of Norwich,

and at the present time mayor of that city (Dr. Eade), was so struck with the success of the treatment that he tried it in two out of five severe and dangerous cases of puerperal fever in women. The two patients so treated recovered; the other three died. These cases, most interesting and important (from many points of view), will be found reported in the *British Medical Journal* of January 22, 1881, p. 116, in a paper contributed by Dr. Eade. It would take too much time to enter into the particulars of this fatal disease and the method of its treatment. For information on these points I would refer you to some correspondence on the subject published by the proprietors of the *Norwich Mercury*, at whose office copies may be obtained. There you will find full directions for the preparation and use of these carbolised oils.

When the time arrives for weaning the lambs, which will be about July 1, preparation should be made to have a supply of cole or cabbages, or a similar kind of food, to feed them upon at night, and during the day they should be run out on clean fresh grass; but on no account allow them to feed on grass growing upon land which may have been fouled by being heavily sheep-fed. Grass grown on such land is pernicious to lambs, and should be carefully avoided. The evil effect may not be observed until much harm has been done. The lambs should have a daily allowance of from three to four ounces per head of mixed bruised heavy oats, linseed cake, and fresh broad bran. Where it can be conveniently given, a frequent change of pasture is most desirable, and any extra trouble or inconvenience this may cause, will be amply repaid by the thriving and healthy condition that it will be sure to promote.

Practical flockmasters are also well aware that great care and attention are required in the management of lambs throughout the months of July, August, and September, when so many thousands are annually lost from a low, lingering, weakening fever, which seems to feed on their very life's blood: post-mortem examinations showing that it leaves an emaciated body, white and bloodless. A cure is most difficult, and is rarely accomplished, if the fever remains unchecked for any length of time. Prevention in this, as in other matters, is far easier, and, therefore, better than

cure. My experience convinces me that injudicious and niggardly feeding is the main cause of this lamb disease. Where lambs are given a change of food of a nutritive character, and are not allowed to feed on pastures or layers where sheep have been folded, or have laid thickly on the ground, they generally remain healthy and are seldom attacked with the fever. "Keep lambs in a thriving condition" is a rule which ought to be written in letters of gold. It is a rule which also applies to sheep of all ages.

Time passes so quickly that I have only a few minutes to speak of the management of young sheep when first fed with turnips. I may, however, briefly observe that great care should be taken to gradually accustom the hoggets to turnips by throwing a few at a time on to grass land where they are feeding, increasing the daily allowance as they get accustomed to the food. After this has been accomplished put them into a fold on the turnip land at night, but in that case also the supply of roots must be limited for a time. When feeding young sheep on turnip land it is of the first importance not to pinch them with insufficient hurdle room. An extra 10*l.* expended in hurdles may save the loss of 20*l.* worth of sheep. A good supply of hurdles enables the animals to get exercise, and to pick up any withered parts of turnips which may have been passed over during the folding. Such withered roots are enjoyed by sheep when the weather is fine, and frequently have a good effect in checking any possible evil from the fresh turnips. It should be borne in mind that good and successful managers supplement the turnip food with a mixture of chaff (if of hay all the better), malt culms, bran, and linseed cake, and are guided in the daily allowance by the time at which they wish to have the sheep ready for sale. When the period comes to feed with swedes, in place of white or other common turnips, care must be taken to introduce them mixed at first, and then gradually to increase the proportion of swedes until no turnips are given at all. Do not overdo them with roots at any time, or bad results may follow. It sometimes happens that under any circumstances a lot of sheep will begin to do badly on roots. When this is the case do not hesitate entirely to change the food for a time. It will avoid disastrous loss. I have frequently known a judicious

alteration of food cause so great a change in the health of a lot of sheep as to surprise their owner and the shepherd in charge of them. A careful, observant, and practical man will frequently avoid the losses which another person, less observant and less practical, is called upon to endure.

Suffer me before I say good-bye to you to give you one more word of advice. This Institute affords you the opportunity of listening to many excellent lectures. From them you will learn much that will be useful to you. Whether what you hear will be of any lasting advantage or not will depend in great measure—perhaps entirely—upon yourselves. Believe me when I say that unless you think over each lecture carefully after you leave this room, you will get little permanent good.

Then, remember, that though lectures and book reading are designed to assist you, they will of themselves never make you good and successful men of business. You must add to theoretical knowledge personal energy, care, perseverance, and economy. *Energy* in performing all your duties with a "will." *Care* that nothing placed under your charge suffers from want of personal attention. *Perseverance* in endeavouring to overcome all difficulties which seemingly stand between you and success. *Economy* in the management of your farms and personal expenses, so as not to spend a shilling in doing that which might with sound judgment and forethought be done equally well for sixpence. Finally, when the time comes for you to enter upon farming, do not be tempted to hire a farm of 500 acres if your capital is only equal to one of half the size. *There is no royal road to successful farming.*

Success such as that we see to have attended those three eminent agriculturists, Jonas Webb, Sam Jonas, and John Clayden, was achieved by honest work—work with hands as well as with head. Work you as they worked, and there will be no reason why even in these adverse times your skill, care, and judgment in the management of herd, and flock, and farm, should not be rewarded with like success: a good honest return for Brain and Capital, sufficient not only for the requirements of the day but for the vicissitudes of the morrow.

SOME SCIENTIFIC ASPECTS

OF

CHEESE-MAKING.

BY BERNARD DYER, ESQ., F.C.S., F.I.C.,

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A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

March 10*th*, 1884.

SOME SCIENTIFIC ASPECTS OF CHEESE-MAKING.

Professor Dyer commenced his lecture by stating that Dr. Kleuze, a well-known writer on dairy matters, enumerated no fewer than 156 varieties of cheeses, more or less distinct. All those varieties were made from milk, with the addition of a little rennet and a little salt. Some were made from skim milk, some from ordinary milk, and some from milk *plus* a certain quantity of cream, while other cheeses were made from cream itself. All the 156 varieties might be classified under those four divisions. It was very curious to realise how those same materials might be made up by manipulation to yield so many products, some of which were quite different. The flavour of new cheese varied very little until it ripened, so that the difference was mainly due to the process of ripening. The question, therefore, they had to ask themselves was, why did different cheeses ripen in different manners? Animal and vegetable substances were characterised by a very marked tendency to undergo changes, which in common life were severally known as decay, fermentation, and putrefaction. It was formerly supposed that those changes were purely the result of chemical action, but the researches of M. Pasteur had successfully proved that, although chemical in their nature, they were originated by minute living organisms, only visible by means of a high power of the microscope. Mr. Dyer then performed certain experiments to prove that putrefaction was caused by the presence of minute organisms in the air. The French chemist, Duclaux, had during recent years devoted a great deal of attention to studying the action of the various organisms upon milk

and its products. When milk was left exposed to the air, it coagulated or curdled; but in the process of cheese-making, instead of leaving milk to curdle, it was curdled by means of rennet, produced by minute organisms which lived in the stomach of the calf. When milk was curdled by rennet in cheese-making, the curd or casein was carried out of solution, and it carried down a greater part of the butter. The curd contained in a new cheese was very indigestible, but when ripened it became digestible. The process of making cheese soluble or digestible was brought about by the action of living organisms, which produced the decomposition of the casein, which was resolved into soluble albuminous substances, alcoholic substances, and ammonia salts. It was those ammonia salts which gave the characteristic flavours to the different cheeses. The reason why different cheeses ripened in different ways was, that in the conditions in which it was manufactured the dairymaid unconsciously was favouring the action of one or other of those particular organisms. The character of cheese was considerably changed by the differences of temperature at different stages of its manufacture, or by the fact of a great deal of whey being left in or nearly all pressed out. The question of locality also changed the flavour. It was a well-known fact that certain cheeses were only produced in certain localities associated with their names. For instance, if they went into an ordinary Cheshire dairy, and took with them an experienced maker of Stilton cheese, he might make a cheese that looked like Stilton, but would not taste like it. The peculiar characteristic which they looked for in Stilton was not there. Scientific researches showed that some kinds of cheese were only produced by some particular races of ferment; and in dairies where such cheeses have been long produced. those organisms haunted the air and were always present. It was impossible to make a cheese in such a dairy without its being infected by the particular ferments which lived in that dairy. It had been suggested that if in an ordinary Cheshire dairy a little Stilton dust containing the germs of the Stilton ferment were sprinkled with the Cheshire it would produce the desired kind of ripening. If that were so it would be an immense advantage to many dairy

farms. In foreign fancy cheeses it was not an uncommon thing for a dairy to have what was known as a "cellar sickness." The cheese-maker found that, for some unexplained reason, the cheese did not ripen as it should, and perhaps for a year or two he was not able to produce the particular fineness of quality that he desired. That no doubt was due to the condition of the living germs in the air. Probably some other ferment that was not desirable had for a time gained admission to the air in that dairy, and had crowded the other out. The organisms which ripened cheese were various, and many of them they knew nothing about. Some of them lived in the interior of the cheese away from the air, while others—those in the nature of mould—grew only on the surface. Roquefort cheese was ripened by the green mould that clung to mouldy bread. That particular ferment grew at a temperature of nearly freezing point, so that in the Roquefort dairy the ripening room was kept at nearly freezing point, in order that that mould might be favoured and the luxuriant growth might produce a characteristic substance which gave Roquefort cheese its flavour. Gruyère cheese, on the other hand, was a cooked cheese. It was heated to a temperature of 120° Fahr. The object of that was to enable the whey to be pressed out more completely. If too much whey were left in, the organisms ripened Gruyère too fast; unless, therefore, the cheese ripened very slowly, it never received a good flavour. If the cheese were heated too much, it became what the dairymen truly called "dead." Cheshire cheese had always occupied a high rank, but there seemed to be some danger that the sale of old Cheshire cheese would diminish. American competition, and the introduction of a good ordinary cheese at a low price, had impelled many of the Cheshire dairy farmers, in order to compete with American cheese, to endeavour to make Cheshire cheese faster. Good old Cheshire cheese took from nine to fifteen months to ripen and become in a condition to eat, while by the early ripening process, the result might be attained in a few weeks. The essential difference between the manufacture of old and early Cheshire cheese was then described.

ENSILAGE:

Its Influence upon British Agriculture.

BY HENRY WOODS, ESQ.,
Merton, Norfolk.

A LECTURE

DELIVERED UNDER THE PRESIDENCY OF

H.R.H. THE PRINCE OF WALES,

BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

March 17th, 1884.

ENSILAGE:

Its Influence upon British Agriculture.

[Abridged Report.][1]

May it please your Royal Highness, my Lords, Ladies, and Gentlemen :—

The title of our lecture pre-supposes, on the part of the distinguished assembly which I have the honour and privilege of addressing, some acquaintance with the silo-process—that method of storage by means of which green crops are preserved and converted into the cattle food called ensilage. Many books have been published on the system, and from time to time our agricultural journals have described at length the opening of silos in various parts of the kingdom, and recorded the results of ensilage experiments, simple and elaborate.

"Never prophesy unless you know," is a maxim for which I have great respect. It was present to my mind twelve or fourteen months ago when, in closing a lecture to the Wayland Agricultural Association, on the "Origin, History, and Practice of Ensilage," I ventured to predict that the silo was destined to become an important factor in the practice of British agriculture—a source of relief and profit to the distressed and almost distracted farmer. Yet, whatever some persons may have thought, there was nothing

[1] This abridged Report has been taken from the full and complete Report published by Messrs. Hamilton, Adams, & Co., London, in which full experimental details, and costs, are furnished by the author.

rash or reckless in this forecast, founded as it was on the data of several experiments conducted at Merton at the instance of Lord Walsingham. This evening I repeat the prediction with still stronger emphasis, and will lay before you, as concisely as possible, the evidence on which I rely in support of my conclusion.

At the close of last year I issued a circular letter with a number of questions addressed to leading agriculturists in the three kingdoms, and the returns with which many have favoured me are exceedingly interesting and valuable. They give detailed information as to the size and character of various silos, the different methods of storing and preserving now in use, and the results so far secured; thus affording a basis for useful comparison.

It is not more than four or five years since the silo experiments prosecuted in America first began to attract attention in our own country. At that time silo and ensilage were terms almost, if not altogether, unknown to us. They were certainly not in the least understood. Notwithstanding the natural sluggishness with which we are credited, we have considerably advanced in knowledge. These terms are now as familiar to us as household words, and the ensiling of green fodder crops is no longer a tentative but an established practice amongst us. Let me here observe that in this lecture I do not intend to use the word "ensilage" as a verb; but will adopt *ensile* as preferable, perhaps more correct, and certainly more convenient.

The national importance of introducing the silo into the agricultural system of Great Britain cannot be too much insisted upon when we consider the conditions under which farming is and probably will be for the future carried on here. It is not the least likely that the cultivation of wheat will be remunerative to the present or even to the succeeding generation of farmers. Cast your eyes across the Atlantic, and look at America and Canada, with their vast unreclaimed territories, which only await the arrival of the husbandman and the plough to yield enormous quantities of wheat for exportation to the English market. With the tide of emigration ever beating on their shores, and with every year a larger home population to feed, these countries must, by the ordinary operation of the laws of supply and demand, be less

and less able in course of time to send us any very important quantities of corn. But were that yet distant contingency ever so near at hand, we should still have but little reason to hope for any material relief from foreign competition. For we have also to take into consideration the almost boundless resources of our East Indian Empire, from whence, through an extended railway system, corn will soon be poured into the markets of Europe in practically unlimited quantities.

Increase our meat supply as much as you may, there is no fear of the demand being outrun and its production becoming unremunerative. Progress in the direction of an increased growth of beef and mutton has of late years been sadly retarded by the importation at intervals of diseases from abroad. The consequent onerous and harassing restrictions laid upon the movement of our home stock have entailed ruinous losses upon breeders and graziers. Despite these drawbacks, there was a slight increase last year, and the farming interest is evidently more and more recognising that its prosperity is inseparably associated with the raising of live stock. It is in this relation that ensilage will exert most influence upon British agriculture. Silently and gradually, yet steadily and surely, it must work a great revolution in our system of husbandry.

I hope to show you conclusively that by the practice of ensilage farmers may breed and graze more stock for the dairyman and the butcher. The practice is adaptable to light, heavy, and mixed soils. Our humid climate, although it favours the development of green fodder crops, renders absolutely unavoidable a great annual loss in the process of securing them, more especially in the case of our autumn cuttings. Under the system of ensilage this loss may be entirely obviated. Of late years many poor, cold, and damp clay lands have gone out of cultivation through the difficulty of finding tenants to take them. In these instances the land has not been sown with grass seeds, but has fallen into a condition which is the inevitable result of that kind of loose cultivation and management to which men are compelled to resort who find their capital diminishing month by month. Common couch and other coarse grasses having naturally got the

lead, it would cost a small fortune to clean these soils, and render them fit to grow corn, or to properly lay them down to grass. But the silo will convert these coarse grasses into useful cattle fodder, and give some return, even though the cultivation is restricted to the stubbing of thistles and obnoxious weeds. Of course, I do not for a moment suggest that ensilage of such grass will equal in value that of finer quality; but it is not too much to assert that even common and ordinary worthless grasses become in a degree more valuable through the changes which they undergo in the silo.

In last year's lecture I reported some remarkably favourable results in the increase of milk and cream from cows fed on ensilage of common, coarse, couch-like grass, which grew under trees in an open oak wood, and had previously been considered of no use whatever as food for horses, cattle, or sheep. This year we filled a silo with grass from the same wood, and it was converted into excellent ensilage. We gave it to cows in November. They greatly relished it, and its influence on their milk was in every way satisfactory.

What, then, is the process by which this great and beneficial change is effected? Mr. Francis Sutton, Public Analyst for the County of Norfolk, and Analyst to the Norfolk Chamber of Agriculture, in his able and highly satisfactory report appended to the Analysis of Merton Ensilage, in 1882, pithily describes it as "a partial digestion." The woody fibre of the plant being softened, its changed condition renders it more easy of assimilation. It is in fact more nutritious than when fresh. With less stimulation of the gastric juices, there is less demand upon the constitution, and therefore less detraction from the benefit derived. The green material put into a well-appointed silo continues in a fresh and wholesome state, and is subject to slower changes than occur in the field. So long as active oxygen, or, in other words, atmospheric air, is kept out, decay will not take place; and without decay there is no deterioration. By the application of sufficient pressure, the air is in the first place expelled, and it is subsequently kept from permeating the mass by the slow but constant evolution of carbonic acid gas. Low

temperature is, of course, of importance. If the process is to produce its full beneficial effect, it is obvious that care will be required in its management. The want of sufficient care has doubtless led to many erroneous opinions as to the value of ensilage. Where the result has been disappointing, I hold that it has been invariably due to a loose and careless, or to a faulty and perverted, method of procedure. Too much must not be expected from the silo. Though it is astonishing what it will do, it will work no miracle.

As I have said, if the silo is to do effective and remunerative work, care and skill must be shown in its management. This is so important to be recognised that I beg you to excuse the reiteration. At the same time it is unnecessary to provide expensive buildings and appliances. Farmers will be neither able nor willing to adopt a system that is costly or complicated. For practical utility, which is the great object, an old disused barn is unsurpassed. It has the further advantage of reducing the expenditure to a minimum. Though silos may vary in their form and character according to the circumstances of particular farms, there is no occasion to lay out large sums upon them, and on most farms, in the present prospective condition of agriculture, there is no margin for fancy buildings. A simple oblong structure, thoroughly air-tight and water-tight, is all that science requires for the successful storage of ensiled fodder.

In the conditions of the process itself, experience has suggested, and practice approved, various alterations in the nature of improvements. Some of these have so direct an influence on the ultimate value of ensilage to British agriculture that I shall offer no apology for referring to them. One defect and drawback which attended the practice in its early application was the re-opening and filling up again of the silo, in order to make good the loss in bulk through the shrinkage that takes place in the material during the first few days after the filling. At Merton we have overcome this difficulty by means of a simple mechanical contrivance, and at a trifling cost, more than repaid by the saving effected in labour, independent of the additional security it provides against re-admitting air into the silo.

This contrivance is what I may describe as a small super-silo—an oblong 2-inch deal box, without bottom or lid, about 30 inches in depth; the sides and ends, which are separate and apart, being brought together and affixed by ordinary bolts and clamps to the wooden coping and walls of the silo proper, and the sides strengthened against lateral pressure by a few iron struts. This simple arrangement costs so little as to be within the means of every farmer. It may be fitted in twenty minutes, and—what is also most important—during the time it is being adjusted the work of filling may proceed without interruption. When we have filled up to the top of the super-silo with chaffed material, thoroughly well trodden down, we put on the surface a cover of cross-tied boards, in three divisions, and spread over these a layer of bran about five inches deep—bran being the most cleanly and useful of all air excludents—and weight them in a manner to which I will presently refer.

Shrinkage, as I have said, occurs chiefly in the first few days after weighting. In less than a week from the filling the mass will have settled to a level with the coping of the silo proper. We then remove the portable super-silo. The subsequent settling from the top of the silo itself varies according to the character of the material; but in our silos (which are 14 feet 4 inches × 6 feet 3 inches, and 10 feet 6 inches in depth) we have never found it to exceed from 20 to 25 inches. Thus the necessity of re-opening and re-filling the silo, to avoid a waste of space, is entirely got rid of, and it is now a rule with us to have only one filling. The advantage of this, in enabling the work to proceed uninterruptedly, and in rendering the whole process more finished and methodical, will, I think, be obvious to all.

Another alteration, and also an undoubted improvement, is a reduction in the allowance of salt, a matter in which I believe mistakes to have been made. After careful observation I am not prepared to concur with those who would dispense altogether with the use of salt; but, so far as I am at present able to judge, the proportion should be about three-quarters of a pound, and in no case more than one pound, to every hundred-weight of the fodder. I would suggest that the exact quantity for each silo should be

accurately weighed, and placed conveniently at hand, so that the men engaged in filling the silo cannot, through inadvertence or carelessness, exceed the allowance.

The question of the best kind of covering for the contents of the silo has given rise to a good deal of controversy. Last year I advocated the use of bran, not only on the ground that it is the most cleanly of all materials, but that, when it has served its purpose on the silo, it may be given to stock, and is thus thoroughly economical. Further experience has confirmed me in this view. I ask you particularly to observe that the bran should be laid *over* and *upon* the planking, NOT under, as has been done in some cases, which will account for the waste, of which complaint has sometimes been made. The settling that follows the filling of the silo cannot be uniform; little "slips" and crevices occur at the sides, and into these the bran particles run, closing them up. Where sawdust or soil is used, you must get an admixture of dirt and grit, which certainly no animals with a regard for their stomachs would care about eating. On the other hand, they will eat and enjoy the little bran that gets mixed with the ensilage. This point, I hope, is now sufficiently clear. A layer of bran over the boards, not less than four or five inches in depth, is the best possible covering. It effectually excludes atmospheric air, and the portion that becomes mixed with the ensiled material does no harm and occasions no trouble when the ensilage is taken from the silo. We have, therefore, made this one of the established rules of our Merton practice.

In no particular, perhaps, has practice differed more than in the weighting of the contents of the silo, both in respect to the amount of weight and the method in which it is applied. This is a point which will greatly influence the results obtained. The silo is much more than a reservoir for preserving—it is a machine for making food, and as such it must be allowed fair play. It is in this relation that the portable super-silo of which I have spoken becomes so valuable an auxiliary. The silo being closed and weighted once for all, the process of fermentation goes on uninterruptedly, and the ensilage contracts, but one crust of slightly deteriorated material, instead of the two which are found when-

ever the silo has been reopened and refilled. On this point it seems that we should gain nothing by further experiment. Our principle at Merton is, therefore, fixed and settled. The proportion of weight we allow does not exceed 70 pounds to the square superficial foot. We also apply the weight in a simple, cheap, and effective way. An ordinary pulley is the only kind of mechanical appliance that we employ, manual labour being all-sufficient.

A number of boxes are filled with common gravel stones, carefully sifted, so that the underlying bran is as free of grit as possible, and not damaged for feeding. These boxes, which have been specially designed, are made of ordinary English wood, are uniform in size, and each hold about 2 cwt. of stones, the dimensions being 24 inches by 10 inches, and the depth 18 inches. The parts are nailed together, tightened by a binding of light one-inch hoop iron. The ends, which are curved upwards, have small openings, through which is passed a movable iron cambrel or handle for attaching a pulley, by means of which the boxes are easily hoisted into position. The time occupied in thus weighting one of our silos never exceeds half an hour.

Various mechanical contrivances for silo weighting, lately brought under public attention, are now in operation. But these, however excellent in principle and successful in working, are luxuries, the cost of which puts them beyond the reach of an average farmer. Of course, there are cases where mechanical compression is indispensable, such, for instance, as where ensilage is manufactured in small concentrated quantities for conveyance off the farm; a point to which I purpose referring later on.

The material was at first packed by our men treading and ramming, the latter operation being performed with rather light wooden rammers. As we observed that, though lifting the "rams" high enough, the men were by no means prodigal of their strength in bringing them down, we provided them with cast-iron, cone-shaped "rams," weighing about 21 lbs., with a handle four feet long. We find that these answer exceedingly well, and are inexpensive. If the foreman sees that the "rams" are reasonably elevated, the men may be trusted to save their muscles by letting them fall quickly enough.

This may be a convenient time to say a word on the subject of long ensilage. Among many samples of ensilage forwarded to me for inspection, I have found that although some which was unchaffed was decidedly good, it was not equal in quality to that which was chaffed. There was a perceptible difference in the aroma. The odour from the long ensilage was such as you would expect to be given off by decomposing vegetable matter, and, in fact, some of the smaller and finer blades of grass were decomposed. The chaffed ensilage, on the contrary, had a wholesome vinous smell, and was fresher and greener in colour. Some persons have complained of being unable to chaff long ensilage after it has come out of the silo. It is not surprising that in a compressed condition it clogs the cutter. We might as well try to chaff a cake of tobacco. The same comparison might not inaptly apply to the process of mastication and digestion. When green it is, of course, easily cut into chaff without any clogging whatever. The chaffed grass also packs much more closely in the silo than the long, so that subsequent shrinkage is greatly reduced. This fact is conclusively shown in the various reports I have received. Without desiring to condemn the ensiling of long grass, I have seen nothing at present to induce me, on the ground of economy, convenience, or utility, to alter our plan of chaffing all material before putting it into the silo.

Many of my correspondents report that their carting went on in wet—sometimes very wet—weather. Now, while it is one of the chief advantages of the silo system that it enables the farmer to gather his green crops under unfavourable conditions of the atmosphere, it does not follow that these may not ultimately affect in some degree the quality of the ensilage. When circumstances admit, it is undoubtedly desirable for the cutting and carting to take place in weather neither too wet nor too dry. A reasonable amount of moisture will be beneficial, and therefore the crops should, as far as practicable, be cut and carted on sunless days, and in times of wet when the rain is intermitted.

We are now in a position to consider more specifically the influence of ensilage upon the agriculture of this kingdom. If the man who causes two blades of grass to grow where one grew

before is a benefactor of the human race, surely no less is he through whose efforts those blades and others hitherto wasted are converted into nutritious food for stock. Ensilage enables the farmer to make this conversion. He may thus avoid the deplorable loss arising from wet haysels, and have in the severest winter a supply of good succulent food, little inferior in its properties to the rich growing herbage of spring and summer. He is further able to bring into useful cultivation unpromising and unproductive land.

It is when turning to the results which have attended the feeding of stock with ensilage that we perceive how vast an influence this new system is destined to exercise upon British agriculture. Of its benefits in this relation the evidence is overwhelming both in volume and in force. In feeding cows we may, I suppose, lay it down as a rule that the more plentiful the food the more plentiful the milk; the richer the food the richer the milk, the cream, and the butter. The quantity and quality of the milk produced by ensilage we therefore assume to be the best test of its value as a food for stock. Taking this test, we find in nine out of every ten practical trials the flow of milk is stimulated, and its quality enriched, by the use of ensilage. Where results have been disappointing, the cause may invariably be traced to feeding too exclusively with ensilage.

Many inquiries have been made as to the suitability of ensilage as a food for sheep. About a year ago I published in a letter the results of a most satisfactory trial with half a score ewes, conducted by Mr. T. J. Gayford, of the Manor Farm, Wretham, one of the most experienced flockmasters in Norfolk. As he had no silo on his farm at that time, the trial was made with Merton ensilage. Satisfied himself as a practical flockmaster, and encouraged by his shepherd's wish that the whole flock of 800 ewes should this season be supplied with ensilage, Mr. Gayford applied to his landlord, Mr. Morris, of Wretham Hall, to build him some silos. That gentleman has liberally responded to his request and has provided him with three large barn silos. Since January 7 the entire flock has been fed with ensiled grass from these silos. The ewes have been throughout in an eminently thriving condition, and

never looked better. The high opinion which Mr. Gayford entertains of ensilage may be inferred from his having stated that if he were about to take another sheep-farm, he should stipulate for silos to be provided, and in the alternative event of the landlord not being disposed to incur the outlay, he would gladly undertake to pay interest on the capital expended in such buildings.

The Merton flock, which consists of 350 ewes, has a daily allowance of ensilage. In December we began giving the ewes, which were fed on park land all through the autumn, a mixture of grass ensilage and hay chaff. They have done remarkably well, so well indeed that there has been no case of bad lambing, and an unwonted absence of all fatality. Never in my experience were we so successful, or fortunate, in whichever way the fact may be regarded. It is true that during the early part of the season the weather was favourable, but that is not in itself sufficient to account for a complete immunity from every kind of sickness, quite unprecedented in the flock.

I ought, perhaps, to mention that in former years it has been our practice to give a liberal daily allowance of a mixture of good hay chaff and fresh bran, at the rate of six bushels of the former to two of the latter; but this year we have dispensed with bran altogether. It is also worthy of remark that when we did give bran the ewes picked it out as much as possible from the coarser parts of the chaff, but now they eat up the chaff perfectly clean. This is apparently owing to its being flavoured with ensilage. The ewes are abundantly furnished with milk, and the satisfactory way in which they perform the duties of maternity is shown by the healthy and lively condition of their lambs.

Some persons might, perhaps, think that while ewes and lean sheep thus eat grass ensilage, it would not be as acceptable to animals in a higher condition, accustomed to a richer kind of food. We are in a position to prove that any such suspicion is groundless. Our exhibition sheep last year were fed on ensilage mixed with other food. They not only liked it, and throve upon it, but our first prize Southdown wethers at Smithfield were the heaviest pen of their age and breed ever exhibited. I am not prepared to ascribe this increased size solely to the virtues of

ensilage. I merely state it as an interesting coincidence. The sheep had an ensilage mixture, except in the summer months, from the time they were eight months old, and were throughout unexceptionally healthy.

Of horses fed on ensilage, my experience is confined to those employed on our Home Farm. In the last two years we have given them ensilage with barley-straw chaff, and dispensed with bran, while continuing the usual allowance of oats. They have been and are remarkably healthy, as the veterinary surgeon knows to his disadvantage.

Two years ago we put a quantity of chaffed grass and other material into casks, ramming it down compactly, and weighting it and covering it with bran, as in the silo. The result was so satisfactory that last year we extended the experiment. The casks, which were of various sizes, were filled at different times between July and September; an operation easily, economically, and expeditiously performed. The ensiled material consisted of maize, oats, brank, spurrey, and common grass. When opened in the present year it was all sound and good. Ensilage thus made and stored would also be an undoubted boon on board steamships carrying cows for the production of milk during a voyage. There is, therefore, no doubt that on well-conducted principles, with the aid of artificial pressure, crops may be ensiled in casks available for the use of cowkeepers resident in large towns.

I have now endeavoured to support by facts and reasoning the proposition that ensilage is destined to exert considerable influence on British agriculture. It only remains to express my regret that it has been impossible for me, by further condensing the material, to reduce my demand upon your patience. A powerful stimulus will be given to the ensilage movement by this influential assemblage, honoured as it has been by the gracious presence of his Royal Highness the Prince of Wales. We are deeply sensible of, and grateful for, the interest which his Royal Highness at all times manifests in the welfare of agriculture. I am confident that within these walls, and in the country beyond them, there will be a general feeling of gratitude to his Royal Highness for having

presided here this evening. He has done this, we feel, not only by reason of that public spirit which, as Prince of Wales, he brings to bear upon every useful and deserving national enterprise, but from sympathy with a struggling yet never more important industry, and as a generous friend to the great agricultural community of this kingdom.

Sir TREVOR LAWRENCE, M.P.: May it please your Royal Highness, my lords, ladies, and gentlemen.—I am sure that I shall carry with me the unanimous assent of this crowded audience, when I venture to propose to the Lecturer, Mr. Woods, a very hearty vote of thanks for the lecture that he has delivered to us. It would be impossible, it appears to me, to have described in a clearer, fuller, and more interesting way, the very important subject that he has chosen to bring before us—a subject which, I venture to think, he has treated with a fulness of knowledge and a wealth of illustration which leaves nothing to be desired. So much that he has brought before us will probably be new to agriculturists who have some knowledge of ensilage that I should not venture, if even I were an agriculturist, to offer any criticism upon it, but if now, after a long period of loss and depression, there is at last opening before the farmers of this country some hope of, by new and improved methods, battling with and overcoming the obstinacy of the elements, then I think a very great debt of gratitude will be owing by the agriculturists of this country to Mr. Woods, to Lord Walsingham, and all who have taken an interest in bringing this new process before the public.

The PRINCE OF WALES: A vote of thanks has been proposed to Mr. Woods. I feel sure I need hardly put it. We shall all unanimously agree to it.

Mr. WOODS: May it please your Royal Highness, my lords, ladies, and gentlemen.—I beg to offer you my best thanks briefly, but most sincerely, for the high honour you have been pleased to confer upon me in according me this proof of your approval of my humble efforts this evening. I am especially indebted to His

Royal Highness the Prince of Wales for his great condescension in conveying the vote of thanks so kindly proposed by Sir Trevor Lawrence. I can only hope that as the subject of ensilage becomes better understood, many of the difficulties by which the agriculture of the United Kingdom is now so heavily weighted may disappear, and that there may yet be in store for the British farmer brighter and better times.

The EARL OF ABERDEEN: May it please your Royal Highness.—I have the pleasure to give utterance to those feelings of grateful appreciation by which your Royal Highness's presidency on this occasion is regarded, not only by this large and influential audience, but, as Mr. Woods has so well said, by agriculturists at large. It is not necessary for me to allude to the immense beneficial influence of your Royal Highness, owing to the great practical interest which your Royal Highness takes in agriculture, in its widest sense, and I feel sure that the expression of our great indebtedness to your Royal Highness will be received by this meeting with grateful acclamation. I beg to propose to your Royal Highness a grateful vote of thanks for presiding on this occasion.

The vote was carried by acclamation.

The PRINCE OF WALES: My lords, ladies, and gentlemen.—I wish to return my hearty and sincere thanks for the cordial reception you have been good enough to give me to-night. The duties you have conferred upon me in making me your chairman to-night have, in place of being onerous and difficult, been not only very light, but have been very pleasant, for I have had the advantage of listening to the most interesting and exhaustive lecture upon ensilage which Mr. Woods has delivered. I cannot claim to have gone thoroughly into this most important and interesting subject at any depth. I have, however, some acquaintance with it, because some sixteen months ago, when on a visit to my friend Lord Walsingham, at Merton, questions in connection with this subject of ensilage were brought under my notice, and my attention was then for the first time drawn to the subject. As to the future, it is of course, impossible to foresee to what extent ensilage may be carried out, but I am convinced from what we

have heard this evening from the lips of Mr. Woods, that those who are moving in this subject are dealing with one of very great importance, and I am at all events assured that we ought to be very much indebted to Mr. Woods and to Lord Walsingham for giving very careful trial to what may prove in future years the means of rendering very great and valuable services to agriculturists. Most cordially do I endorse the remarks which fell from Sir Trevor Lawrence, that even now, after the hard times which the farming interests of this country have suffered for some years, there is a prospect of the great interests which are involved in the agricultural question having a brighter future before them, and that a new gleam of light may be thrown upon their fortunes by the successful carrying out of this new experiment in agriculture—this question of ensilage. Most cordially and sincerely do I hope the experiments which have been made, and their results, may be of advantage to the agricultural community. I thank you again for your kind welcome of me to-night, and again congratulate Mr. Woods upon his most excellent and interesting lecture.

GERMINATION OF SEEDS.

By PROF. G. T. BETTANY, M.A., B.Sc., F.L.S.

A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

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THE GERMINATION OF SEEDS.

THE subject of the germination of seeds is one in which pure science and practical experience come very close together. The agriculturist, whether he is concerned chiefly in corn raising or in fodder production, or whether he takes up the departments of vegetable or root growing, cannot help occupying himself much about seeds. He either wishes to produce good seeds, or good plants from seeds. Many around me, I am sure, must have a practical acquaintance with the subject which it is totally impossible for me to attain, and it would ill become me to trench on their province, and on that of the distinguished director of this Institute. But to the botanist and vegetable physiologist the word germination is full of suggestion, combining as it does apparent simplicity with the profoundest consequences.

The botanist thinks of the young plant hidden in the seed in a state of rest from which it has to be awakened, the passive to be made active, the dry to become moist. The physiologist, knowing the condition of the ripe seed and that of the growing plant, feels the force of the contrast between the two, and the word which to him is most significant in considering the work done is that which indicates agitation and active change, namely *ferment*. What the changes are which the plant undergoes in germination, and how they are produced, is in effect the subject of this lecture.

Firstly, as to the structure of the seeds which we want to germinate. Without going at all into the processes by which they are formed, let us take them as ripe seeds, smaller or larger

masses separated from a parent plant, capable of producing, under favourable conditions, a plant like the parent in all essentials, though it may differ in minor points, in height, in number of leaves, in weight, &c.

The true seed of a flowering plant is one of the features by which it is most markedly characterised, so that it would be possible by that alone to be certain that it was not the product of one of the non-flowering plants, a fern, a moss, a mushroom, or a sea-weed. The seed of a flowering plant is a more advanced structure than the spores which the non-flowering plants produce; it contains within itself a miniature or embryo plant which has already made some progress in development, and manifests in most cases those distinctions into parts which are of prime importance, namely, root, stem, and leaves.

Such a seed as the bean, when ripe, contains nothing of importance except the young plant. When the skin is peeled off, the rest of the seed readily falls into two divisions; yet these are not totally separate, but connected at one side, near the spot where the seed was fixed to the pod. These two large lobes, each being nearly one half of the seed, looking extremely unlike ordinary green leaves, are yet, in a botanical sense, the first two leaves of the plant—the seed-leaves, often called cotyledons. And from this peculiarity of having two equal seed-leaves fixed opposite one another to the rudimentary stem, the great proportion of our flowering plants, including the cabbage and turnip tribe, the rose and apple family, the pulse and clover group, the mangel and the oak, are called dicotyledons.

At the point where the two seed-leaves are fixed, there is a little stem, which is continued one way (pointing towards a little hole in the seed-coat), into a cone-shaped growth, the *radicle* or commencing root. Passing in the opposite direction is a little portion of stem bearing a few very small leaves. These are flattened and folded together so that they lie snugly between the seed-leaves near their edge.

Now this represents the plan of all the seeds of what may be called the highest kind, where the structure is the most advanced. We meet with great differences in the size of the seed-leaves, as

well as varieties in their contents. They are sometimes found folded double or even treble, as in various members of the cabbage tribe.

But there are many seeds among those with two seed-leaves which have not proceeded so far towards simplicity of structure. In addition to the minute rudimentary plant, they may have a store of nutriment between their thick seed-coats and the small embryo; and this in many plants constitutes the main bulk of the seed, as in the carrot and parsnip. It has often been called albumen, a bad term, because it has a definite chemical meaning, whereas the substance to which it is applied in seeds has a great variety of chemical composition. I will speak of it only as the embryo food. It is the store upon which the young plant is at first fed. The main difference between the bean and the carrot seed is that the young bean plant has eaten up all the embryo food, while in the carrot seed the embryo is small, and a quantity of embryo food remains unconsumed. And thus we consider the bean as a higher type of seed, because its embryo has already got within itself all the food which the parent plant afforded it, while the little carrot plant has its embryo food in large part outside itself, and in germinating has to set to work to absorb something external.

Our grain plants, as well as the palms, of which the date affords a familiar specimen, have seeds containing both an embryo and embryo food, the latter usually of much greater bulk than the former. Consequently, wheat, barley, Indian corn, &c., consist of a much greater amount of embryo food than of embryo plant. Then again, the embryo itself is framed on a different plan. We do not meet, in these grains, with a pair of equal seed-leaves or cotyledons. Just as in the growing corn we find the leaves wrapped up beautifully one within another, so it is in the young state. They arise alternately one on one side of the young stem, the other on the other, and fold one over another.

But the first of the young appendages—that which is of most importance in the actual germination—extends, in a seed like maize, right over the rest of the young plant, so as to overlap both the young bud of small leaves and the young root, and it is in

contact by its outer edge, in its whole extent, with the embryo food. It is by means of this surface that the young plant feeds upon and absorbs the stored-up food.

Next, as to what these seeds consist of chemically. As in the entire plant, and in the manures or foods necessary for it, these substances can be classified as nitrogenous and non-nitrogenous; and inasmuch as the simpler kinds of nitrogenous bodies, ammonia and the nitrates, do not become solid deposits in plants, this term nitrogenous will here principally apply to complex bodies, albumen, casein, gluten, fibrin, and, speaking generally, proteids, all of which contain carbon, hydrogen, oxygen, nitrogen, and sulphur.

When the seed was advancing to maturity, it, of course, included a large proportion of these complex bodies, which go to make up the living substance or *protoplasm* of plants. At the end of the drying process it is not the case that all this living substance is wasted or decomposed. After parting with very much of their water, the nitrogenous substances appear as dry bands between the starch granules, or as little grains, sometimes of no definite shape, sometimes resembling true mineral crystals very closely. In one or other of these shapes the nitrogenous matter, by which the living plant is to be again started on its course, is preserved during the dormant or resting period. Nay, so completely and thoroughly is the continuity and descent from the parent plant maintained, that the little corpuscles of living substance out of which the future green granules of the plant-leaves are to be developed, are continuous descendants of corpuscles in the seed of the parent plant, to which the term starch-generators is becoming applied. For the main function of the green granules in leaves, as of their colourless representatives in store organs, such as seeds and tubers and roots, is to form starch and allied substances.

By far the most abundant of the non-nitrogenous constituents of seeds is starch, which occurs in the cells or units of which the cotyledons or seed-leaves consist, and in the embryo food, in the form of countless granules, of characteristic shape and size in almost every plant, usually packed closely in the cells, with the little spaces between them devoted to the albuminous

matters just spoken of. I will only refer to the fact that the starch granules consist of layers having slightly different amounts of water combined with them. Also, they are not quite simple chemically, consisting of two nearly allied compounds intermingled, giving slightly different reactions.

Very closely connected in percentage composition is the material of which the cell walls are composed—the cellulose membrane. When starch is abundant—or something equivalent to it—the cell-membrane is thin. But in some seeds, as in the date-stone, it is extremely thickened, so as to form almost the entire mass of the seed, and actually take the place of starch as the food store to be drawn upon during germination.

Yet another kind of non-nitrogenous body has to be mentioned, namely, oil. The oils occurring in seeds agree in being composed of carbon, hydrogen, and oxygen, and in having comparatively little oxygen. Oils are abundant in many seeds which have little or no starch, such as the castor-oil seed, rapeseed, linseed. It is found in minute granules and in smaller or larger drops in the cells, between the nitrogenous grains or particles.

Having now reviewed the condition of the seed when ripe, let us determine what shall be regarded as the close of germination. One way of determining this is to take the period when the plant would die if grown in the dark as the end of germination. For it is well known that seeds can germinate completely in the dark if supplied with a sufficient quantity of water and kept at a suitable temperature. As an actual fact it is found that most plants begin to take up food from the air by green leaves considerably before all the reserve food in their seeds has been used up. Gradually they pass from the condition of germination to that of youthful independence; and perhaps the best definition of the cessation of germination is that period when the young plant ceases to draw upon the reserve in the seed.

The young turnip or wheat plants, springing from comparatively small seeds, are much earlier independent than peas or beans. So also the maize, grown in the dark, has such a considerable store in its seed that it can live for seven or eight weeks, and then the embryo food is found to be used up.

Between these two extremes of the ripe, hard, dry seed and the young plant in vigorous life with a strong hold upon the earth by means of numerous root-fibres and a multiplicity of absorbing root-hairs, with a succulent stem growing every day firmer and more capable of supporting the weight of numerous leaves, and with leaves in sufficient abundance to abstract enough carbon for the building-up of the plant substance from the air, we have to survey the changes, material, chemical, or other, which occur.

The first thing necessary to the germinating seed is water. Until the seed has swelled it cannot be said to be started on its course of germination. The seed, on an average, may contain about 10 per cent. of water, much of it involved in the very chemical structure of the starch, cell-membrane, and albuminoids of which it is composed. This is nothing like sufficient as a medium with which to carry on active changes. The amount of water absorbed by seeds before the commencement of germination proper is—wheat, 45 per cent.; maize, 40 per cent.; peas, 106 per cent.; various beans, 100 per cent. 1,000 grammes of air-dry kidney beans containing 12 per cent. of water were weighed, and after 24 hours' soaking in water the cotyledons contained 767 grammes of dry substance and 1,004 grammes of water. When the skin and radicle had got well developed, the cotyledons contained 708 grammes of dry substance and 1,397 grammes of water. When the cotyledons had become green, and emerged from the seed-skin, they contained 508 grammes of dry substance and 1,816 grammes of water. At the end of germination, when the cotyledons had very much shrunk, they contained 228 grammes of dry substance and 1,772 grammes of water. Comparing the relations of water to the cotyledons and to the rest of the embryo, namely, the young bud, stem, and root, minus the cotyledons, at the end of 24 hours' soaking, the embryos, minus cotyledons, contained 5 grammes of dry substance and 11 grammes of water. When the stem and radicle had become well developed, the same gave 18 grammes dry substance and 180 grammes of water. At the third period 107 grammes of dry substance and 1,247 grammes of water; at the end of

germination, 283 grammes of dry substance and 3,222 grammes of water.

This will suffice to show the enormous importance of water in germination, constituting nine-tenths of the weight of the plant at its close, and furnishing the most striking contrast to the condition of the ripe seed. It is impossible, indeed, to over-estimate the necessity of a suitable abundance of water in securing satisfactory germination. The plant will not in so doing take up more than it can dispose of. It puts all its water to the best use, as the vehicle of all the transport of material that necessarily takes place in it, as a necessary ingredient in the living and moving protoplasm of its cells, and in enabling the reserve materials of the seed to take a soluble form. Only one other ingredient from outside is essential to the progress of germination, and that is oxygen. The access of free atmospheric oxygen is as needful for the young plant as for the young animal.

It follows from this that seeds must not be too deeply buried, otherwise the access of oxygen may be too limited for their proper development, in addition to the amount of the sun's heat growing deficient as we recede from the surface. Some interesting experiments have been made to decide at what depth below the surface the largest proportion of seeds would germinate. In the case of cat's-tail grass (Phleum pratense), 100 per cent. germinated at four-tenths of an inch deep; the proportion diminished to 92 per cent. at an inch and a-half deep, when a great fall was observed; and between a depth of 3 and 5 inches, less than one-third of the seeds germinated. In regard to Indian corn, there was a considerable difference; less than half came up when laid close to the surface, two-thirds sprouted at an inch or more beneath, while the full percentage only germinated when the seeds were buried three inches deep. With trifolium, again, the greatest number sprouted when sown close to the surface, within half an inch; while, when they were buried an inch and a-half, only one-sixth were successful. On the whole, there is preponderant evidence in favour of seeds being sown near the surface as to their probabilities of successful germination; although in practical agriculture this matter is, we are only too well aware, complicated by the risk of their being

eaten by birds and other enemies, who often get much more of our carefully stored and selected seeds than are allowed to reproduce their kind.

But another consideration enters into this matter of the depth to which seeds may be buried, and this must be referred to later in speaking of the relative size of seeds. At the present moment it is desirable to speak of the mineral ash present in all seeds, associated with the cell-membrane, the starch, and most especially the albuminous or nitrogenous matters of the seed. Although it is not known precisely in what way the salts constituting the ash are associated with or essential to the life of the plant, it is quite certain that they are essential, and even that during germination an additional quantity becomes absorbed. The total ash of ripe seeds varies from 2 to 4 per cent. of the dry weight. In winter wheat one-third of this quantity was found to be potash, and nearly one-half phosphoric acid in a combined form. One-eighth was magnesia; and there is no mistaking the significance of the potash, the magnesia, and the phosphate, as showing that a due supply of these ingredients is of the highest importance to the formation of suitable seeds. It is evident that there is a close connection between the nitrogenous bodies and phosphates, although it is impossible at present to say with confidence what the relation may be. But, as an actual fact, germination is impossible without this ash, and without its travelling from the situations in which it occurs in the ripe seed to those new parts which soon begin to appear when germination has set in. Other ingredients of the ash of wheat, in much smaller quantities than the three principal ones I have mentioned, are soda, lime, iron, oxide, silica, and a little chlorine and sulphur. In peas we find more potash than in wheat, and less phosphate and magnesia, but both the lime and the sulphur are in larger proportion.

The condition of the seed at the commencement of germination has now been reviewed, and the necessity for the addition of water and oxygen as outside ingredients has been mentioned. We will assume that a suitable temperature is attained. As to light, it is well known that germination will take place in the dark if water and oxygen be supplied. Thus, we can now

inquire what happens within the seed, by means of which the root is put forth, the new leaves are sent up, and the store of food gets diminished. Very soon after the swelling of the seed, the granules of nitrogenous, albuminous matter may be seen to become more gelatinous and viscous, and gradually to give rise to a ground substance resembling in appearance the former protoplasm while the seed was ripening. The portions of substance which had a crystalline appearance dissolve. In particular, the nuclei of the cells return to their ordinary condition, and this is especially the case in the parts at the tip of the little root and at the growing point of the stem. This is very quickly attended with a swelling of the cells in these situations, and the rapid formation of new ones, by which the root tip is forced out of the seed-skin, and the increase in growth of the young stem and leaves begins.

But inasmuch as the living protoplasm of these new cells is very largely composed of nitrogenous, albuminous material, it is evident that the quantity of this kind of material in the root and stem and young leaves must increase. It is proved experimentally that it does so increase, while in the large cotyledons of beans and peas, and in the embryo food of maize, it diminishes as germination proceeds. Yet it is one of the fundamental properties of protoplasm in plants not to travel through cell-membranes from one region to another, even when they are so very thin as they are in young germinating plants. The different albuminous constituents of protoplasm do not travel by diffusion through cell-membranes. How, then, can we account for the presence in the growing parts of this increased amount of albuminous matter? One obvious source is the albuminous matter in the resting parts of the seeds. But the transfer cannot take place without a distinct chemical change in the compounds. That which is not diffusible, and cannot travel through the cell-membranes, has to be so transformed that it can pass through them—can penetrate through the invisible pores between the molecules of the cell-membranes, and travel from place to place in the growing plant, the active parts, by the changes which take place in them, creating a demand for more material to continue the processes which are there in progress.

Those who are familiar with animal physiology will realise that here is a problem very much akin to that of the digestion of food in the stomach. Albuminous matter taken in in a non-soluble form in meat, in eggs, in milk, in bread, has to be transformed into a soluble condition, in order that it may pass through animal membrane into the blood. And, just as in animals, the required chemical change is effected by the action of a ferment known as pepsin, so in seeds the digestion—for it is nothing less—of the stored-up food is effected by one or more kinds of ferment. A ferment, chemically speaking, is a body which in some way assists or presides over changes in other substances, without itself being used up proportionally to that change. It exists in very minute quantity, and there is no proof that it itself becomes changed in the process of transformation. In many cases the change consists essentially in the addition of one or more molecules of water, but in others there may be a considerable splitting up of the albuminous matter.

Numerous seeds when germinating contain ferments capable of transforming albuminoid substances into peptones, which are able to pass through cell-membranes. Plant pepsin, according to Gorup Besanez, has quite similar powers to animal pepsin. The ferment itself is very little, if at all, changed or used up. The presence of an acid is required, as in human digestion.

There is a considerable amount of evidence that the most complex nitrogenous bodies during germination split up into two kinds of substances, one nitrogenous and the other non-nitrogenous, and that these nitrogenous bodies can travel to the spot where new growth is going on, and there be re-combined with non-nitrogenous matter to form complete protoplasm. A number of nitrogenous compounds, which can only be derived from the albuminous bodies, make their appearance during germination, and contain considerably less carbon and oxygen than they do. One of the most studied of these is asparagin, which derives its name from common asparagus, in which it was first discovered. It is abundantly developed in many leguminous seeds during germination, although when ripe, and before the commencement of germination, it is not present in them. It has been found also

in barley and maize, and some think it is invariably formed during the progress of germination. It is most highly diffusible, and it appears very possible that by combination with sugar derived from starch this body could be the means of regenerating protoplasm, and furnishing it to the growing parts.

I here recur to the fact that oxygen is essential to germination, and proceed to comment on the corresponding facts that carbonic acid and water are very considerably formed and given off by germinating seeds. This is the true respiration of plants, as of animals, and is most conspicuous in the germinating state of plants, because it is then that the most active changes go on in a small bulk; every part of the embryo plant is leading an active life at the same instant. Thus, when twenty-four grains of wheat, weighing in the dry state 1 gramme, were placed, after soaking, in a closed glass vessel, after seventeen hours they began to germinate, and at the end of twenty-one hours the air in the vessel contained $2\frac{1}{2}$ cubic centimetres of carbonic acid, and had lost that amount of oxygen. When three soaked beans, whose dry weight was 1 gramme, were left in a closed vessel for forty-eight hours, during which time they put forth roots one-fifth to two-fifths of an inch long, the contained air included nine cubic centimetres of carbonic acid, and had lost an equal amount of oxygen.

These facts are most significant when their meaning as to weight is considered. For every thirty-two parts of oxygen absorbed, forty-four parts by weight of carbonic acid are evolved. The gas given out has increased in weight more than one-third. We can thus see why the dry weight of germinating seeds, independently of the water they take up, decreases considerably until they have begun to absorb carbon for themselves by means of green leaves from the air. Thus, forty-six wheat grains, weighing when dry $1\frac{2}{3}$ gramme and germinated in the dark for seven weeks lost nearly one gramme of dry weight, nearly half the loss being carbon, another half oxygen, while the nitrogen and the mineral ash remained stationary, showing how tenaciously the young plant keeps its nitrogen and its ash.

Now why have I introduced this matter of the loss of weight in germination in this place, notwithstanding that the starchy

constituents of the seed are believed to furnish a great part of the material which is lost in this way? It is because I wish to emphasize what is the controlling influence in this oxidation—this respiration. Notwithstanding that the starch may yield the fuel for this burning or oxidation, the oxidation would not take place but for the activity of nitrogenous living substance. The starch might remain long in contact with water without undergoing such oxidation. It is the living substance in which is the fire, which is, in fact, itself the fire beginning to build up and tumble down as soon as it gets to work, and in that tumbling down, wasting, grinding itself down, so to speak, and by its very activity drawing towards it fresh fuel, fresh food, just as surely as the busy activities of the populations of great cities draw to them perpetually renewed stores of beef and milk. Consequently, we find that as soon as the seed begins to germinate, the starch which it contains begins to be dissolved. The starch is simply one of the resting states of that kind of body known as the amyloids, or the carbo-hydrates, in which the hydrogen and oxygen are present in the same proportion in which they are in water, not in the form of water, but in a very much more condensed form.

The change which the starch undergoes is something more than solution. True, the starch is dissolved; it disappears. But if it still remained chemically the same it would not pass through cell-membranes. It is very noteworthy, in connection with the chemical structure of starch, that the change which is necessary to enable it to take a diffusible form, in which it can pass from place to place in the plant, consists in the addition of a molecule of water to its constitution, whereby sugar is formed. But this change does not ordinarily take place without the development of a special ferment which acts the part of a beneficent busybody, setting afoot and keeping in activity the transformation. An important ferment of this kind is *diastase*, which is tolerably well known to occur in malt; but numerous others are known. Diastase, however, is that which has been most completely isolated, and its effects most carefully studied; and it has been found that one part of diastase can convert 2,000 of starch by weight into soluble products in a few minutes,

supposing an acid is present. This ferment diastase has been proved to occur in oats, wheat, maize, and rice. In a certain experiment 76 parts of cold starch paste were taken and four parts of ferment solution added. In two minutes there was a complete solution of the grains. In half an hour no more reaction with iodine could be obtained, showing that starch was completely absent. The solution then contained 45 per cent. of sugar. Formic acid is the acid most favourable to this process, and this acid is readily formed by the oxidation of starch itself, great part being given off as carbonic acid and water, while the remainder becomes formic acid.

There is now good reason to believe that the starch so converted into sugar is the principal food of the protoplasm, becoming available for continually building it up anew. It is singular that the plant in germinating does not lose any appreciable quantity of nitrogenous compounds; these keep pretty much the same, although we have evidence that the compounds themselves are continually changing. The bodies which diminish during germination are the starchy bodies, whose products, carbon and water, can be and are given off. Maize germinated twenty days in darkness decreased in dry weight from 130 to 70 grains, the starch and dextrin having diminished from about 100 to 10 grains.

But it may be asked, what is the condition of germination in those seeds which do not contain starch, but only very thick cell-walls of cellulose like the date-stone? The cellulose perfectly replaces the starch, and becomes in its place the food of the little germ. It becomes dissolved and transformed by a ferment, and actually starch is manufactured in the process, being very near to cellulose in chemical composition. A similar fact has been discovered in the germination of those seeds which contain much fat and oil, though there is this difference, that in order to produce starch and sugar by the transformation of fat, a much greater quantity of oxygen must be combined with the fat, and associated with this there is much formation of carbonic acid and water. During this active change, as in the date, starch appears in a solid form, temporarily, though not present in the

ripe seed. The importance of the availability of fat being proved is shown by the fact that no seeds are quite without fat; in wheat and oats the fat is 2 per cent., in maize 5 to 8 per cent., in linseed 30 per cent., in rape 40 to 50 per cent.

I will not refer to the temperature of germination, but this is of the less importance because practically we are not able in farming operations to control this. We all know the unfavourable influence of frost on germination. Many seeds germinate very quickly under favourable circumstances, especially cruciferæ and grasses. But the period varies in the same species under apparently identical conditions. The greatest longevity appears to appertain to the peas and beans—fifteen years; but practically three years is the limit within which you may expect the great bulk of seeds to germinate. Still, the extensive keeping of seeds for three years is not to be recommended, as the natural period of germination is the year after the ripening of the seed. But it is valuable to keep stores of the seed of various years in case of failure in subsequent years.

As to the relative value of larger and smaller seeds I may be allowed to say a few words. The larger seeds in general produced by a given plant have a stronger germination, and thus have a greater vitality. In the case of beans and peas, in large seeds the lengths of root-axis were in the proportion of 150 to 130 produced by smaller seeds. The same is the case with the number of root-fibres and the length of stem. This advantage in germination continues till the plant is fully developed. It is a good start, and leads to the production of a better stem, more seeds and better seeds. In the larger seeds of peas and beans it is the cotyledons which are the largest. The roots of the larger seeds penetrate with greater ease into the deeper layers of the soil. They may also be buried or sown deeper in the soil than smaller seeds. In every way it is advisable to sow the heaviest and largest seeds you can get.

I have thus given a brief outline of the processes which occur in the germination of plants. The result of the processes is of undoubted interest, namely the development of healthy young plants. It is very striking that with the exception of water

the young germinating plant derives nothing from the soil, and with the exception of oxygen nothing from the air. How important then are the due breaking up of the soil that oxygen may have free access, and the supply of water. The knowledge of the composition of seeds and the changes which take place in their constituents during germination, may be of service to all who wish for an intelligent comprehension of processes they see every day going on around them. This may show the reason for a choice of large seeds and the utility of microscopical and chemical examination of seeds. The fact of highest interest to a biologist, however, is perhaps the close parallel which is found to exist between digestion in animals and the conversion of the food stored up in seeds into materials available for feeding the growing germ. Thus we see exemplified—the unity of life, the similarity between the early stage of a seedling and the adult form of the highest animal, the proof that plants as well as animals digest their food, and that the distinctions between them are but minor compared with the great and fundamental bonds which unite them.

THE TWO
MILDEWS OF CORN.

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THE TWO MILDEWS OF CORN.

THE disease of wheat popularly recognised as Corn Mildew, is the best known and most widely spread of all plant diseases. It sometimes entails a loss of from 50 to 75 per cent. to the agriculturist. It is not so well known that the familiar rust of corn, as seen in the spring and early summer, and the black mildew of autumn and winter straw, are only different conditions of one and the same fungus; and it is still less generally known to farmers that there are two perfectly distinct corn mildews which invade our crops every autumn, and that each of these black mildews arises from a distinct rust. Botanists who believe that one of the mildews completes its cycle of existence on a Barberry bush, assure us that the second mildew has no connection whatever with the Barberry, but completes its life cycle on various plants belonging to the Borage family.

One species of rust appears much earlier in the season than the other; this one may be termed spring rust. It has long been known to botanists as a pest of corn, and it was described as British in 1836 by the Rev. M. J. Berkeley, in *Hooker's British Flora*, under the name of *Uredo Rubigo*. Mr. Berkeley at that time described it as common, but not so injurious as the true mildew, named *Puccinia graminis*. *Uredo Rubigo* is now more commonly known as *Uredo Rubigo-vera*. The name *Uredo* is derived from *uro* (to burn), and refers to the burnt appearance of the disease spots on wheat leaves. *Rubigo-vera* means "true rust," it is the rust of spring-time, and quite different from the summer rust, which appears later in the season.

The subject of the mildews of corn may be approached from various points, and as farmers first become acquainted with the pests every year in the spring when the stems and leaves of their cereals become rusted, we will start with the familiar rust of spring—*Uredo Rubigo-vera*—the destructive fungus which, although it sometimes entails great losses on farmers, is innocent of all supposed connection with a Barberry bush. The spring rust of corn appears in March, April, and May. It not only invades cereals, but is common on Soft Grass (*Holcus lanatus*), Creeping Soft Grass (*H. mollis*), Barren Brome Grass (*Bromus sterilis*), Wall Barley (*Hordeum murinum*), and other grasses.

It is very common to hear practical men—especially men who have little or no time for scientific study—say they do not want to know anything about the names and natures of the pests which invade their fields; all they want to know is how to get rid of them. Such men, to a considerable extent, are perfectly right, for it does not matter to them how many legs a fly may have, or how many joints it may have in its antennæ; the chief point to every practical man simply is, how to kill the flies or ward off the attacks of the fungi.

Now it unfortunately happens with men of science—and it does not matter whether they are botanists or medical men—that a great deal more is known of the aspect and nature of disease than how to cure it. It does not follow that because a doctor may have a complete knowledge of the nature of scarlet fever, that that doctor can save the life of a patient who has been badly assailed. It is the same with plant diseases: a man may know all about the nature of corn mildew, the potato disease, or club-root, and yet be unable to indicate how certain crops are to be saved. It frequently happens, however, that the doctor or botanist, as the case may be, can indicate how diseases in animals and plants may be prevented. It is proverbially acknowledged that prevention is better than cure. It is obvious that it is useless to attempt the cure of a man whose lungs have both gone, or to cure the potato disease when all the potatoes have turned putrid. In the case of every disease the one great thing to be chiefly sought for is less cure than prevention.

Now, the act of warding off disease is like fighting with a dangerous and merciless enemy. If we know all about this enemy, if we understand his appointed and certain period of appearance, his strength, and his equipment, we may have some chance of coping with him. To surely baffle him we must know all about him—we must force him to show his cards. When we have the enemy in the light and know all his weak points, we may perchance give one or two successful thrusts.

It will be my duty this evening to explain as well as I am able the nature of the two rusts and their accompanying mildews of corn, and then to show as well as my ability will admit if rust and mildew can be prevented.

Every one knows that doctors sometimes differ as to the nature of a disease a patient may be suffering from. One may say it is in the base of the lungs, the other that it is in the liver. The same fact holds good with several plant diseases, and opinions differ as to the life history of the fungi of corn mildew. I, however, do not intend to appear as an advocate for either side. No one denies the phenomena and facts belonging to mildew. It is the deductions made from the known facts that are disputed. I will therefore confine myself to a statement of facts, and I will inform you of the deductions that have been made, so that you may form your own opinions of their reasonableness or unreasonableness.

To begin with spring rust, *Uredo Rubigo-vera* (it is on the young spring wheat now), its time of appearance is March, April, and May. If part of a wheat leaf be taken that has been invaded by rust, it will be seen covered with small pale yellowish spots. These spots are termed by botanists sori or pustules. It is evident on a microscopical examination that the disease growth is within the leaf, and that the epidermis of the leaf has burst in an irregular fashion, and displayed the yellow disease matter within. The microscope shows that the yellow material is a very fine powder which may be blown off or dusted away with the hairs of a fine brush. Sometimes this powder is produced in such profusion in the corn-fields that it dusts with yellow colour the boots and clothes of persons who walk

through the corn-fields of spring. If we make a transverse section across one of the smallest pustules, we shall see the yellow dust under the epidermis of the leaf. We now observe that the yellow powder consists of enormous quantities of microscopic yellow spores or seeds, each spore being supported on a slender stalk. This is the *Uredo*, or rust spore, or seed.

These rust spores are produced in diseased cereals and grasses in uncountable millions; they are shed in vast numbers from the disease pustules, and littered all over the leaves on both sides.

Now it is probable that every one in this room knows that the epidermis or skin of a leaf is not in one continuous piece, but is made up of many little transparent cells packed side by side like a thin stratum of microscopic bladders, and that between these bladders there are numerous little orifices opening into the body of the leaf. The orifices are like the entrances to a castle or camp; they are the weak points by which an enemy can, if favoured by fortune, enter into the interior of the leaf from the outside. The little openings are sometimes popularly termed breathing pores; out of these little pores the living plant exhales a fine watery vapour. The orifices are mostly on the under surface of the leaves.

The constituent cells of the cuticle of a leaf are very large in comparison with the spores of a fungus. Uredo spores germinate very readily as soon as formed, in moist air, and under similar conditions of moist air the stomata or breathing pores, properly the organs of transpiration of plants, are open at their widest. In dry air spores refuse to germinate, and in dry air the organs of transpiration of plants become closed.

We will suppose a Uredo spore to be on a moist leaf of corn on a damp April day. All the organs of transpiration of the wheat plant will be wide open. The invading fungus spores germinate by bursting at both sides and sending out long tortuous runners, or spawn threads. These threads grow very quickly, and they run down the microscopic furrows found on every wheat leaf. These furrows are like paths leading to the entrances of the camp; in the instance before us, to the interior of the leaf; and as every gate is wide open in the moist air, the spawn thread enters

the interior of the leaf, from the outside. Once inside the leaf the spawn or mycelium is in a suitable position for growth. It is now like a root in the ground, or a fish in water.

When once inside the leaf, the spawn ramifies in different directions, and spreads disease in its course. It produces vast numbers of new spores within the leaf, and these spores in turn form new spore pustules. From these new pustules the Uredo spores are littered out; these spores again germinate on the leaf surface, and again find access to the interior of the leaf by other organs of transpiration. This process is repeated over and over again till, in bad cases, the entire wheat leaf is covered with livid yellow or orange disease spots. This is spring rust, and none of the facts I have mentioned have ever been denied or questioned.

As the autumn months approach, the pallid or yellow rust spots become brown, and afterwards jet black. This is mildew. The same spots which were yellowish in spring are black in autumn. The change in colour has been brought about by the change in the nature and colour of the spores, which have all along been produced within pustules. As the spores or seeds become different in form and colour, so botanists have given them a different name. Just as the fungus is called rust in spring and mildew in autumn, so the fungus is called by botanists Uredo in spring and Puccinia in autumn. The Puccinia which follows *Uredo Rubigo-vera* is termed *Puccinia Rubigo-vera*—Puccinia is a proper name given in honour of Puccini, a famous Florentine professor.

If we now take a fragment of a wheat leaf in autumn, we shall see the disease pustules black in colour. Black powder is discharged from these pustules, not orange, as in March, April, and May. If we cut a very small pustule across transversely and look at the cut surface, we shall see the spores to be jet black when seen in a mass; these spores are a somewhat pale rich brown when seen in a single series. It will be observed that the autumn spore is not a simple oval body like the Uredo spore of spring, but a compound one of two segments, or a spore with a partition or septum across its middle. Botanists call these brown septate spores by the uncouth name of teleuto-spores, from the Greek word *teleutao*, a finishing. The word is used in the sense that

these brown septate spores are the last produced spores of the rust and mildew fungus. They are also very commonly termed resting spores, for the reason that they will not, as a rule, germinate at once in damp air or upon moist leaves, but go to rest, or hibernate. As a rule, these spores rest like many seeds; nothing will induce them to germinate at once, they will not be hurried. They rest in the straw, and when the corn is harvested they still rest. When the straw dies, they do not die. If the straw is used for litter in the stable or farmyard, these teleuto-spores will rest. The treading of flocks or herds or horses does not injure them; however they may be saturated in the stable or farmyard, still these teleuto-spores quietly rest uninjured. Drought does not dry them up, and the sharpest frost does not injure their vitality. They remain in a deep stupor or sleep all through the winter till the following spring. During this time the straw as manure will probably have been again carted on the fields, and in this rotten straw and dung of spring the teleuto-spores are still alive, sound, and healthy.

In the spring, and just at the time when spring rust first appears in our fields, these Puccinia spores, or teleuto-spores, or resting spores, germinate on the rotten straw and grass. They germinate by throwing out either one or two transparent germ tubes called promycelium tubes. Promycelium, of course, means the first produced mycelium, or spawn—the mycelium which begins the life cycle of the fungus. After this promycelium has grown for a short length it twists like a shepherd's crook, a few septa or partitions are formed, and from each little section thus cut off a small, faintly-tinted amber-coloured spore is borne; these spores are termed promycelium spores, because they are borne by the promycelium, and are the first spores of the season.

Up to this point no difference of opinion exists amongst botanists as to the facts I have recorded, but at this point a very serious difference of opinion occurs. It might have been assumed that in the Uredo, the Puccinia, and the Promycelium spore we had the larva, pupa, and perfect condition of the fungus complete, and that as the promycelium spores are produced at the very time when the rust reappears on our cereals in spring, that these

promycelium spores are blown on to the crops, and there reproduce rust at once. The promycelium spores germinate very readily in moist air, and will germinate on any moist surface, unless corrosive, whether organic or inorganic. Many observers believe that rust is reproduced direct from the promycelium spores, but others step in and say, Not so; the promycelium spores only germinate effectually on members of the Borage family, as the *Bugloss*, *Lycopsis*, *Alkanet*, *Anchusa*, *Comfrey*, *and Symphytum* of our fields and hedges, and in germinating on these plants they produce not a Uredo, but an apparently totally different fungus named *Æcidium asperifolii.* This Æcidium goes through its own life history, equally complicated with that of rust, and at last the germinated Æcidium spores are said to become parasites on grasses, and produce, not an Æcidium, but a Uredo.

No observer in this country has ever been able to make promycelium spores of *Puccinia Rubigo-vera* grow on Borages, and so artificially produce an Æcidium. The reverse experiment of placing Æcidium spores upon the leaves of cereals for the production of the Uredo has not been possible, as so few persons in this country have ever seen the Æcidium on Borages in a living state. Mr. Plowright, who advocates the connection of the two parasites, has, in an experience of thirty years, never gathered the Æcidium. My friend, Dr. Cooke, who has especially sought for the Æcidium for a still longer period, has not lighted on it more than twice, or at most three times. I have studied fungi daily for fully thirty years, yet I have never once seen it in a living state, and on its being recently necessary for me to produce an illustration of this fungus for publication, I was forced to rely upon a dried example procured from a foreign country.

Facts like these impress some people with the idea that the Æcidium on Borages has very little to do with the spring rust of corn, or if the two fungi are in any way connected, the rust gets on quite as well without the aid of the Borage as with it.

The consideration of this point is of the greatest importance, as the gentlemen who advocate the connection of spring rust with Borage blight are the same who advocate the connection of the

summer rust with the blight of Barberry bushes, and objections that apply to one apply with equal force to the other.

I regret that owing to the rarity of the Borage fungus, I am not able to produce a drawing of it, or even exhibit a dried specimen. This is of little importance to practical men, as virtually the parasite appears to be absent from this country. It is only right that I should say here that the absence of the Borage fungus in Britain cannot be taken by itself as a proof that the spring rust of corn and the blight of Borages are not connected, as the spores from the Borage fungus might be blown across the sea from the Continent—they might be blown across like the well-known clouds of aphides and ladybirds. No clouds of spores belonging to the Borage fungus have, however, ever been detected travelling through the air, and I do not know that the fungus is anywhere common, even on the Continent.

We will now leave the destructive spring rust, with its accompanying black mildew, and notice the summer rust. Spring rust, as I have before said, appears in March, April, and May. Summer rust seldom appears till June or July. The fungus of summer rust is termed by botanists *Uredo linearis*. The name Uredo I have explained; *linearis* refers to the linear or streak-like appearance of the disease pustules.

The Uredo of summer rust is less livid or yellow in colour, and more orange than spring rust. Summer rust is altogether larger and more robust in growth; it splits and lacerates the cuticle of the affected plant more completely, but the description already given of the life history of the spring rust generally applies to summer rust. The pustules of the latter are much larger, and the Uredo spores, which are a little different in form and size, are supported on longer pedicles or stalks. When the spores of *Uredo linearis* are littered over grass leaves, they germinate like the spores of *U. Rubigo-vera* by bursting at both sides; the germ tubes then travel down the microscopic furrows of the leaf, and enter the organs of transpiration. Here, as in *U. Rubigo-vera*, they form a new mycelium, from which arise other large pustules, which soon again burst through the cuticle till the rust or Uredo growth is sometimes extended all over the invaded plant.

As the autumn advances, the orange pustules become black, and (as in spring rust) the summer rust is succeeded by a Puccinia, in this instance termed *Puccinia graminis*. Like the last, the brown septate teleuto-spores, or last produced spores of the Puccinia, go to rest in the straw, and sleep in the barn, the stable, or the farmyard all through the winter. They remain uninjured in the same way as the teleuto-spores of *Puccinia Rubigo-vera*, and in the spring, when the straw frequently finds it way back to the fields in manure, the spores wake up and germinate. They retire to rest later in the season than the spores of *Puccinia Rubigo-vera*, and so they remain at rest later into the early summer. The spores of *P. Rubigo-vera* often show renewed vitality in March, whereas the spores of *P. graminis* seldom wake up before June. When they return to renewed life they burst by protruding promycelium tubes. These promycelium tubes bear little pale lemon-coloured spores termed promycelium spores, and these amber-coloured spores are carried away from the decayed straw and grass by the wind.

At this point we arrive at the old difficulty; some observers declare that these promycelium spores give direct rise to summer rust, which invariably reappears at the precise time of their production; other observers assert that these amber-coloured promycelium spores can only grow on Barberry bushes, and that when they so grow they do not reproduce a Uredo, but an apparently totally different fungus named *Æcidium berberidis*.

Before dismissing this part of the subject, I may call attention to the fact that the rusts of spring and summer and their accompanying black Pucciniæ are as closely allied to each other as any two species can possibly be. They are adjoining species in floras, and sometimes one plant is mistaken for the other by persons who do not examine closely. Under these circumstances one might have expected their second or Æcidium forms to be also allied, and these forms to occur on the same plant, in the style of the two Uredos and Puccinias which both grow on corn. One might have expected both Æcidia to grow either on Barberries or Borages, but, as we have seen, this is said not to be the case. The Berberidaceæ and Boraginaceæ belong to different divisions of

flowering plants. I do not bring this forward as an objection, but as a note to be remembered in the consideration of the subject before us.

We will now turn to the Æcidium fungus of the Barberry, a fungus by no means easy to procure, as farmers acting under the advice of one section of botanists have now almost exterminated the Barberry bush. It does not, of course, follow that when a Barberry bush is found it will be afflicted with the fungus named *Æcidium berberidis*, still the fungus is frequent where the Barberry bush does exist. The name *Æcidium* is derived from the Greek, and should be properly written *Œcidium*; the word means "a little chamber;" *berberidis*, of course, means that the parasite belongs to the Barberry.

The Æcidium almost invariably grows on the under surface of the leaves, although it may on rare occasions be detected on both sides. The Æcidium growths form little clusters of sulphury yellow spots on a dark brown base of hypertrophied or abnormally swollen leaf-tissue. If we examine the upper surface of the leaves we shall see similar reddish patches, but these patches on the upper surface are more or less covered with little black dots technically termed spermogones, or cysts containing spermatia, or flasks containing material comparable with the pollen of flowering plants.

If we look at the black dots with a strong lens, we shall still, owing to their excessive smallness, only see them as black dots, but if we look at the Æcidium clusters with a similar lens, we shall see companies of beautiful sulphury yellow cups bursting open through the lower epidermis of the Barberry leaf, and each cup filled with yellow powder, like extremely small pollen grains.

To understand the nature of the Æcidium cups and the black spermogone dots, we must cut a section through a Barberry leaf, and this section must be so made that it will pass through the centres of some of the cups and spermogones. The spores inside the Æcidium cups grow in chains, and as the ends of the chains emerge from the leaf the spores drop off and are carried away by the wind. For several weeks the growth of the spores is renewed from the base of the Æcidium cups and the chains.

The spermogonia at the top of the leaf consist of threads of brownish mycelium massed into minute balls, with all the threads at first pointing to the centre of the ball or spermogonium. At length these threads show a tendency to grow upwards, and ultimately push through the epidermis of the leaf. When they have so burst through, they break up into fine dust, or spermatia, bodies comparable with pollen grains. When the Æcidium cups and spermogonia have reached maturity, the brownish septate mycelium within the leaf breaks up and is lost to sight.

The spermatia borne on the upper surface of the leaf attach themselves to the spores borne in the cups on the lower surface. The spores do not germinate readily, but sluggishly, after being kept in wet air for several days. This tardy germination seems to indicate that they are potentially resting spores. The supposed fertilisation by the spermatia indicates the same fact. On germination a tube is protruded generally in a convolute fashion.

We now once more reach the old point of uncertainty and difficulty. A certain number of botanists declare that the life cycle of this Æcidium is complete in itself; others state that the Æcidium spores will not enter the organs of transpiration of Barberry leaves, but will only enter the stomata of corn and other grasses, and that in the latter position they produce, not an Æcidium, but a Uredo, viz., a *U. linearis*, or the fungus of summer rust. Spring rust is said to jump over to Borages, and summer rust to Barberries.

I will now impartially review the evidence for and against this interchange of host and total change of appearance in the rust and mildew fungi, withholding nothing from either side as far as my knowledge goes.

The first we hear in regard to a possible connection of corn mildew with Barberry blight is that a popular belief existed amongst rustics 100 or 200 years ago to that effect. I am inclined to estimate this part of the evidence at a very low figure, especially as the last century rustics did not always select the Barberry. In some places they suspected the Thorn, which often bears a not dissimilar yellowish fungus with that of the Barberry. In other places rustics believed that the Barberry fungus caused Bunt in

corn. An equal number of rustics disbelieved in all four, or that Mildew, Bunt, Barberry blight, and Hawthorn blight had any connection with each other. Some of the rustics believed that the effects of Ergot were due to witchcraft.

An obsolete Act of Parliament dated 1738 has been brought forward as evidence of the connection. This Act says the connection was believed in, and orders Barberry bushes to be exterminated. At the same time an Act was passed for punishing witches by hanging, and an official witch-finder was appointed who consigned many innocent old women to the gallows. Old popular beliefs and obsolete Acts of Parliament must not be accepted as representing facts for to-day without sound corroborative evidence.

The opinion of the late Professor J. S. Henslow is often quoted as being in favour of the connection, but if reference is made to his writings it will be found that he by no means accepted any connection. He certainly says that some evidence seems to favour it, elsewhere he says the evidence is in the opposite direction.

Then the opinion of Sir Joseph Banks is brought forward. Sir Joseph was no doubt an admirable observer, but he knew nothing of parasitic fungi, and only guessed that the rust of corn and blight of Barberries might be the same with each other, because they were of the same colour.

Mr. William Carruthers, F.R.S., the botanical adviser of the Royal Agricultural Society, believes in the connection of the two fungi, but in his paper published in the *Journal of the Royal Agricultural Society*, whilst he has printed a good deal of evidence in favour of the connection, appears to have overlooked the evidence against it.

Mr. C. B. Plowright, of King's Lynn, has also recently published two essays on the subject of Corn Mildew. In the first he indicated that he thought one disease had very little to do with the other, but in the second he changed his mind and said he believed that one really did cause the other.

In 1865 Professor De Bary, of Strasbourg, published an essay, in which he stated that he had artificially produced the blight on Barberries by infecting them with the germinating black spores of

the mildew of corn. One would have thought that the well-known popular beliefs had led Professor De Bary to make these experiments, but, strange to say, we are assured it was not so, but because, amongst other reasons, "experience had taught the practical farmer that it (the Barberry) was prejudicial to the wheat crop." It appears to me, then, from this statement, that it must have been the popular belief after all that led Professor De Bary to try the experiments.

Many botanists agree with the views expressed by De Bary that a connection really exists, but others, as Dr. Cooke, Dr. Farlow, one of De Bary's own pupils, myself and others consider the connection as unproven.

Mr. C. B. Plowright, of King's Lynn, has of late strongly upheld the connection of the two fungi, and with the object of making the connection more strikingly apparent has recently published a series of illustrations of the subject in the *Gardeners' Chronicle.* All the illustrations are original but one; the original ones represent the well-known germination of the spores of the fungi of Corn mildew and Barberry blight; it is very easy to see this germination, and no one has ever doubted the mode of germination. One illustration is not original, but a copy. It represents a spore of a fungus of Corn mildew germinating on and sinking through the cuticle of a Barberry leaf.

Now, without attempting to detract from the value of Mr. Plowright's admirable work, we think if he had produced an original drawing of this wonderful phenomenon it would have been of more worth than all the rest of the illustrations put together. No one has at present ventured on an original illustration of this phenomenon except one observer, and it unfortunately happens that this single illustration has been so often copied and re-copied that most freethinking botanists now feel angry at the mere sight of it.

I am able to produce no such illustration, simply because, although I have tried hard, I have never been able to see anything of the sort.

Mr. Plowright records that in experimenting with mildew spores on wheat, in one instance rust appeared, and in other plants of wheat, not inoculated with spores, no rust occurred; this

indicates that rust might have been produced from the germinating mildew spores.

The opponents of the connection of the two fungi point to the fact that corn mildew is equally bad, if not indeed worse, in New Zealand and Australia than in Britain, and in the former countries there does not exist a single native member of the Barberry family.

The gentlemen favourable to the connection refer to instances where mildew of corn has been decidedly worse than elsewhere when the corn has been seen growing near a Barberry bush, but Dr. Cooke has published an instance observed by himself of a Barberry bush growing close to a corn-field, and the corn being in precisely the same condition near the bush as elsewhere in the field.

The botanists who have recorded their experiments with spores of mildew and Barberry blight say the resulting fungus appears from eight to twelve days after the planting of the spores. Other botanists, perhaps over cautious, but remembering what advances of growth fungi can make in eight or twelve days, consider this lapse of time between the planting of the spores and the appearance of the new fungus casts a strong shadow of doubt over the meaning usually attached to the results. A man might scatter mignonette seed in his garden, and after a lapse of twelve days see a crop of chickweed on the beds. The evidence should in such a case be unimpeachable that the chickweed plants had really sprang from the mignonette seeds.

The believers in the connection of the two fungi always strongly advise the extermination of Barberry bushes. In answer it may be said that this advice has been given for so many years that very few Barberry bushes are now left to exterminate in Britain, yet there has been no decrease in mildew, and in Australia and India, where there are none to exterminate, the case of the farmers is worse.

All botanists are agreed that mildew is perennial and hereditary in corn; no one doubts this point. Being so, agriculturists must bear in mind that the experimenters with spores have carried out their tests on plants notoriously saturated with hereditary disease.

Wherever the Barberry bush is, there we may find the Barberry fungus. Wherever there is Corn, there we find mildew. Both fungi being so common, and there is hardly any other fungus

than the Æcidium ever seen on Barberries, it follows that the results of experiments should be received with caution.

The case is different with spring mildew and Borage plants. The Borage, unlike the Barberry, is very seldom indeed (almost amounting to never) plagued with its Æcidium. Now, when botanists, including Mr. Plowright himself, try to infect Borages with the spores of spring mildew they almost invariably fail. The disbelievers, therefore, say that the believer can always produce the Æcidium on a Barberry, a plant which always has the disease without inoculation, and that they can never produce it on Borage, simply because that plant is naturally free from it.

There can be no doubt whatever that many diseases of plants, like some diseases of animals, are hereditary, and that the disease is carried down from one generation to another in the seeds. This being the case, the results of all inoculation from fungus spores in plants, already notoriously saturated with hereditary disease, should not be received too avidiously.

Many well authenticated instances are on record of seeds taken from diseased plants producing diseased seedlings, and other seeds taken from healthy parents producing seedlings free from disease. In some cases the seeds have been sown in adjoining rows, and one row has remained perfectly healthy whilst the other has been diseased through the entire season.

Mr. Plowright recently read a short paper before the Royal Society, in which he recorded the occurrence of the Barberry Æcidium on berries of a garden Mahonia, and he thought as Mahonias possibly grew in some Australian gardens that the Mahonia might there bear the Æcidium, and cause mildew. There is no evidence of the Æcidium being in Australia. Some of the infected berries were sent on to me, and although I, as well as Mr. B. S. Williams, the famous nurseryman of Upper Holloway, made repeated efforts to make them germinate, not one would grow. This fact seems to indicate that the plasma of the fungus is capable of reaching the seed itself, and in bad cases actually destroying it.

It has been said that an analogous case of change of form exists in the animal kingdom in the case of insects which have a

larval, pupa, and perfect state, each state being different in appearance from the other two; but this is a very bad argument, as in insects the three series can be traced by the eyes, and each one gradually leads on to the other. Besides, one condition of an insect is never entirely lost to the sight for a month, and if the connection of Puccinia and Æcidium is accepted there are not three states of the fungus only, larva, pupa, and perfect fungus, but at least six states that it might be very difficult to characterise.

The last argument that is brought forward by the believer in the connection of the corn mildew fungus with that of Barberry blight is this. They say the case of Entozoic worms is analogous. These worms, as is well known, pass part of their existence in one animal and another part in another, and perhaps a totally different animal. No one doubts this fact. It has been repeatedly proved by experiments, but the experiments have always been made with animal that were perfectly well known to be free from the parasites before the experiments were commenced. In the case of corn mildew it is equally well known that the hosts are not free from taint.

This brings me to an objection which I cannot help looking upon as fatal to the connection of Corn mildew and Barberry blight. Although it has been present to my mind for many years, I have never urged the objection in print, neither do I know that any other observer has advanced it before. Its importance to my mind, however, far outweighs other objections, and to me it seems to strike at the very root of the structure built on the supposed connection.

It is this: In the Entozoic or parasitic worms referred to there are but three stages in the animal's life—the larva (answering to caterpillar), the pupa (answering to chrysalis), and the sexually perfect animal.

In one state only is the animal sexually mature and capable of producing eggs. In the fungus it is very different, for not only are there three states of existence in the mildew, but there are potentially the three same states in the Æcidium.

In Corn mildew we have first Uredo of rust, next Puccinia, or mildew, from the same base. Puccinia spores are, as I have said,

generally and correctly termed "resting spores"; they are not spores of a simple nature like conidia, but complex in nature and destined, as a rule, to rest like seeds. On germination these resting spores produce promycelium spores. Now, surely the promycelium spores are the larvæ, the Uredo spores the pupæ, the Puccinia spores the perfect state.

If we turn to Æcidium, the fungus of the Barberry, we find an almost similar series, the Æcidium spore fertilised by the spermatia from the spermogones proving the Æcidio-spore to be sexual, and on germination potentially capable of producing promycelium and promycelium spores precisely like Puccinia, as is proved in the case of *Æcidium Euphorbiæ-sylvaticæ*, D.C. In this species the promycelium spores germinate, and produce what Tulasne terms a sporidiole, or secondary spordium. The promycelium spore then, surely stands for the larvæ, the sporidiole for the pupæ, and the Æcidio-spore for the sexually mature plant.

Personally, I do not believe a fungus is comparable with a flowering plant, so that I should be the last person to say it is comparable with such an animal as an Entozoic worm.

My objection, in short, is that there are two sexual states,—resting spores or eggs being potential to both Puccinia and Æcidium.

A short time since I asked Dr. T. S. Cobbold, F.R.S., probably the highest living authority on Entozoa, if he knew of any instance amongst Entozoa of a double series of eggs, one sort of egg being produced by the larva in one animal, and a second sort being produced by the sexually perfect animal in another host. He replied:—"I give a distinct negative to your question, without prejudice to the proven fact of dimorphism amongst parasites, and, of course, also without the slightest reliance on the authority of Mègnin, whose erroneous views imply that two sorts of eggs may belong to parasitic conditions of one species."

It would seem by this answer that the false idea of one parasite arising from two series of eggs has had an advocate even amongst zoologists.

In bringing this address to an end, I may say I do not doubt a

single fact brought forward by the believers in the connection of Corn mildew and Barberry blight. I simply consider the deductions they have made from the known facts as not proven. Cereals are notoriously and constitutionally subject to mildew. Barberries are notoriously and constitutionally subject to blight. Is it not reasonable to suppose that when these plants are kept under unnatural conditions and inoculated with fungus spores this tampering with them sets the latent hereditary disease in action? There are many analogous cases in the animal kingdom. If a person is constitutionally subject to cancer, give that person a blow on the breast and cancer often appears; the blow does not originate the cancer, it merely sets it going. Children are often born with latent hereditary disease; if these children are badly nourished or ill-fed, the disease often bursts out at the time of vaccination. The shock following an accident will often set a latent hereditary disease going. A mere cold will set consumption going in one patient, rheumatic fever in a second, and scrofula in a third. Facts like these are so well and generally known that gout is proverbially termed "a jealous complaint," and with those liable to it will always come and look in if any accident or ailment whatever should arise. If certain irritating articles are taken as food, they will cause with one person neuralgia, with another shingles, with a third indigestion, with a fourth diarrhœa, and with a fifth local inflammation. When all these facts are taken into consideration—and I could easily make them ten times as many —I think, without disrespect to the opinions of other observers, that we had better put the connection of Corn mildew with Barberry blight on a suspense account, and let it be considered unproven till, at least, more decisive evidence is produced.

In conclusion, a few words must be said regarding the prevention of corn mildews; this is undoubtedly the chief point to be aimed at in the study of the subject.

In my opinion mildew is largely propagated by mildewed straw being used in the fields mixed with manure. In this material we invariably have the undoubted resting spores of mildew, and they undoubtedly germinate at the time of the first appearance of rust in the spring or early summer. As there cannot be resting

spores of mildew in chemical manure, or in bone meal or bone superphosphate, it follows that the latter cannot propagate the disease.

Mildew is said to recur frequently after clover, but one reason for this may be that mildewed straw is frequently laid on the old clover plants in manure.

An alternation of crops, with turnips, clover, beans, peas, or potatoes, must be beneficial, as the fungus of corn mildew cannot exist on these plants.

Chemical manures that will ensure a sturdy and hard, as opposed to a rank, soft growth, must also be beneficial to corn in its efforts to resist mildew.

But to my thinking there is but one way of getting rid of Corn mildew, and that is not by cutting down Barberry bushes or pulling up Borage, but by always selecting seed corn from plants known to be free from mildew. No seed corn should, on any account whatever, be harvested from mildewed plants.

Every agriculturist who grows his own seed should be especially particular in this respect. If possible one part of the farm should every year be set aside for the special cultivation of perfectly unmildewed seed.

If the great agricultural seed merchants would take the subject in hand, and sell seed guaranteed to be taken from plants that were perfectly free from mildew, in the course of time we should have wheats, both white and red, free from the disease. It cannot be too well remembered that the disease is hereditary, and every grain of corn from a diseased stock has mildew in its tissues before planting.

Undoubtedly mildewed straw should not be used as manure, as the resting spores of mildew are, without exception, always in this material. Even if it should be conclusively proved at some future time that corn mildews do really pass part of their existence on Barberry bushes and Borage, yet under any circumstances mildewed straw should not be used as a manure for corn. For other field crops it may often be used with safety.

DAIRY FARMING.

By JAMES LONG, Esq.

A LECTURE

DELIVERED BEFORE

THE INSTITUTE OF AGRICULTURE, SOUTH KENSINGTON,

March 24th, 1884.

DAIRY FARMING.

In speaking of dairy cattle the Shorthorns were first referred to, and were highly recommended as one of the most, if not *the* most, valuable cow for a milk-seller or butter-maker, more especially if his dairy be carried on in connection with corn-growing and beef-making. There are numerous instances of extraordinary butter-making by Shorthorn cattle, but there is perhaps no race in Great Britain which has done such great things, so far as regards yield of milk, as this race, and at the present moment Lord Warwick's, Mr. Tisdall's, and other records stand out as probably the best results which have been obtained by any race in any country.

With regard to Ayrshires opinions differed, and here, continued Mr. Long, I may quote a well-known American writer, Mr. Henry Stewart, who recently informed his readers that the Ayrshire was not only equal to the Jersey as a butter-maker, but that it was the best for cheese-making, the only good cow for the production of milk for infants, that its veal and beef were the cheapest and best, and that, in fact, it was more appreciated and more generally kept in the large dairy districts of England, and by the London dairy-men, than any other race. Such is one of the many extravagant estimates published by American writers, not only upon this but upon other races of cattle; and yet the foremost men in Scotland, such as Mr. Lorne Stewart, Mr. Bartlemore, and others, have recently made and sent me statements, which I included in my

Report to the American Government, to the effect that there was no real data to be had in their country, and that it was almost impossible to get any reliable figures as to either butter or cheese-making by the Ayrshire cow. Mr. David Allen, a veterinary surgeon with large experience among Ayrshires, says that the best yield, 750 gallons per annum, give 275 lbs. of butter and 550 lbs. of cheese; but although I believe this is not an over-estimate with regard to the very choicest cattle, yet from what I have seen in such herds as the Duke of Buccleuch's, Mr. Hoggan's, and others, I have come to the conclusion that while such animals as these are to be had, it is only at an immense cost, whereas the generality of Ayrshires purchasable at market prices are extremely moderate beasts, and although more than usually valuable where the feed is poor and the situation bleak and cold, are easily surpassed by some of the other races whether for milk-selling, butter-making, or cheese-making.

With regard to the Red Poll, which clearly is not so largely patronised as it ought to be, I am of opinion that much will be done in the future, for it is a thorough good all-round farmer's cow. It feeds well, is an extremely deep milker, and, as can easily be shown, gives milk of a richer quality, as a race, than any but the Channel Islands breeds. A glance through the description in the "Herd Book" should satisfy any person, but if he needs convincing by ocular demonstration, I would suggest a visit to such herds at those of Mr. Lofft, Mr. Gooderham, Mr. Biddell, or Mr. Colman, and then to try one or two animals for himself. The work done by this race in its own county is so eminently satisfactory, that it can only be because it is not better known that it is not more extensively bred in other parts of England.

In describing the Jersey and Guernsey races the records of Messrs. Fisk and Glynn, of the Isle of Wight, may be cited as examples, both of which have been very kindly sent to me. Mr. Fisk's herd averages 6½ lbs. of butter per week per year, while in the height of summer thirteen selected cows averaged 12 lbs. of butter each. In Mr. Glynn's case his Guernseys average 650 gallons, some of the best cows giving 1 lb. of butter from eight quarts of milk, these animals being in the fields almost all the

year, and in mid-winter having nothing more than open sheds for protection. At the Dairy Show his cow showed fat 5·54, solids 14·25, and cream only 7·5, one more proof of the absolute uncertainty of the cream test as a guide to the quality of milk. Mr. John James, in a report recently furnished, gave the average of a herd of Guernseys for ten years as 616 gallons per cow, many of these cows in their prime giving from sixteen to twenty-two quarts, and $1\frac{3}{4}$ lb. to $2\frac{1}{2}$ lbs. of butter per day. At one of the dairy shows three Guernseys were tested by Dr. Voelcker, and showed 5·88, 5·35, and 4·45 of fat. The Devon was next briefly referred to, not because it is at the present moment adapted for dairy work, but because its milk is so rich (almost invariably showing from 5 to 6 per cent. of fat) that feeders of the race could with a little care and selection easily develop its milking properties, and make it an admirable one for the purpose of butter-making.

Referring to cross breeds, as especially valuable for dairy purposes, the Lecturer recommended a cross between the Devon and the Jersey, some specimens of which he saw recently, and which were of the very highest type of dairy-cow, and, withal, extremely handsome and infinitely superior to a cross between the Shorthorn and the Jersey, crosses of which have been bred in the stable, and which, in very many instances, have proved exceptionally fine milkers. In some of the cheese-making districts the Shorthorn-Ayrshire cross is extensively used, not only because it is a capital milker, but an extremely hardy beast. One of the very best crosses, however, for real work is that between the Red Poll and the Jersey, which is as hard as nails, handsome, very typical, and a rich and deep milker. There can be no doubt that the Guernsey would also make a good cross with some of these races, but having had no experience of it, he preferred to say nothing more about it. Of Continental dairy races, one of the best was the Cotentin, of France, a hardy beef-making breed, which generally used in the Camembert cheese districts, as well as largely by the farmers who manufacture the Brie cheese. At one of the French dairy shows a *bande* of four of these cows took the milking prize, giving an average of twenty-eight litres each. Among the

best milkers of the Continent are the Dutch and the Oldenburger of North Germany, which races are very similar, very large, good feeders, and extremely deep milkers, but both yield milk rather deficient in fat. The next best races to these, at all events in North Europe, are perhaps the Jysk and Angeler of Denmark, many of which are now coming to England, and some are actually in London dairies at the present time. The Angeler is an especially desirable race, being as small and as fine in shape as the Jersey, of a delicious bronze-red colour, cheap, a wonderful milker, and one of the only foreign races of character which can be imported into this country.

Here Mr. Long referred to the recent report he had received from Inspector Buus, of Denmark, giving details of the astonishing performances of his race for several years past, and which will be published in a separate form. Coming to the system upon a farm, he said it might be divided into three—first, the system of breeding, or the production of high-class dairy cattle; second, the system of feeding and management; and, third, the system of dealing with the milk. That herd, he continued, is not likely to be over-successful where great thought and care are not expended in regard to breeding, using only first-rate milkers both as regards quality and quantity—quality being most desirable in these days when the dairy farmer should be able to turn his hand to either milk, butter, or cheese: in fact, breed is all important, and without it, it is of little use to feed, at all events under a complete system; but where breed is combined with first-rate management and judicious feeding, there can be no doubt of the result.

The feeding of cattle does not form part of this lecture, but it must be remarked that the only way to obtain a maximum from a cow is to feed her upon that food which gives the best return, and to give her only so much of it as will give the best profit. This can only be done by constant attention, by watching the individual cows, and keeping a record of each, for it is possible to feed too high as well as too low. Cakes of various kinds—linseed, cotton, rape, chestnut, and pumpkin seed—are used in different parts of Europe by dairymen, as well as ground grain and pulse of all kinds; but there can be no doubt that in a general way ground oats, bran,

and pea hulls are as good as anything which can be used, especially when cost is a consideration, and that parsnips and carrots are the best of any kind of root. I have tested whole oats, some persons having stated with authority that the cow, in consequence of chewing the cud, would properly masticate the oat and derive greater benefit from it; but this is not the case, for the great majority pass through the system entirely undigested. For milk-selling I highly recommend pea meat and grains, ensilage, of course, being used wherever possible, for the results I have seen in France from the use of this food are such as to remove all doubt as to its value.

Lastly, with regard to the system which pays best in the dairy. If milk is sold, the farm should be near a station, but, however this may be, inasmuch as the influence of the weather and the exigencies of the trade sometimes subject the milk producer to great inconvenience and loss, he should be able and prepared at any moment to convert his milk into cheese or butter, and so be independent of both the middleman and the large milk companies. Milk will pay well at 8*d.* a gallon all the year round, but much less than this ought not to be accepted, as by a good system it can be obtained in another way, the cost of carriage, which is enormous, in comparison with that in other countries, having much to do with these results.

If the dairy is a butter dairy, it is above all things necessary that the cattle should be specially adapted to, or bred for, the purpose; for the cow which will give an average of 6 lbs. or 7 lbs. a week costs no more to keep than that which gives only 3 lbs. or 4 lbs., and it makes all the difference to the profit—perhaps, indeed, the existence, at all events the continued existence—of the farmer. There is one important feature with regard to making butter and cheese—the farmer should make his own market, and if he has a good article to sell he should not have much difficulty in doing that. To rely upon the dealers and factors, and to take exactly what prices they choose to give, is out of the question, although so generally done; and when it is remembered what an enormous demand for dairy produce there is in this country, and that it is simply a question of replacing foreign producers, the dairy farmer should have no hesitation as to his course of action,

and no fear as to the result. With a good system of manufacture he will obtain a good market, and, consequently, a satisfactory result. If the dairy is sufficiently large to employ a separator (and when the new small Danish machine is before the public, as it will be shortly, the majority will be in a position to use it), the separated milk should be sold, and this will add from 3*d.* to 4*d.* a gallon to the proceeds. It was at first stated that it would be difficult to sell this milk, but directly it becomes known the only difficulty is to provide it in sufficient quantity, its price, sweetness, and longer-keeping qualities make it of inestimable value to the consumer; while as to giving it to pigs—when it contains 8 to 9 per cent. of solids, each pound of which is of more value than its weight in beef, and not half as costly—that should only be thought of as a stop-gap, or when everything else fails. A butter-maker's cow should at the very least yield 1 lb. per ten quarts of milk. Upon this basis, then, and estimating separated milk at 3*d.* a gallon, we get 2*s.* 1½*d.* to each pound of butter, allowing the butter to be 1*s.* 6*d.* a pound, or considerably less than the average obtained by existing factories; or, after deducting for cost of manufacture, at least 8*d.* a gallon, or much more if labour is not charged for, as in the majority of cases it would not be.

With regard to cheese, it is essential to understand more than one system. I am not referring to English hard cheeses, for inasmuch as the makers of Cheddar and Cheshire are already very numerous, and as America sent us since last May 1,700,000 lbs., so much of which competes with these makes, I take it that it is another class of cheese to which we should turn our attention, and which at the present time is yielding so great a profit to the Continental market. Cheshire dairies produce about 4 cwt. of cheese per week, or from 19*l.* to 21*l.* per head per annum, whereas makers of the foreign soft cheeses reap from 25*l.* to 35*l.*, and it is their trade which the English people should be in a position to check, and to increase in this country for themselves. To sum up, therefore, it may be assumed that a ten-quart cow, as referred to above, giving an average of eight quarts a day, will pay for milk at 8*d.* a gallon, 21*l.*; for butter at 1*s.* 6*d.*, 29*l.*; and for British hard cheeses, 20*l.*, it being understood that in the butter

dairy separated milk should be sold or converted into a tasty and valuable cheese.

In milking there are two important things to be remembered, first, to prevent the milker dipping his fingers in the milk, a regular trick when no one is watching, as it enables him to milk easier; and, second, to entirely empty the udder, the last milk retained being the richest. When drawn, the milk should be weighed upon a small spring balance, the milk at once strained into the cooler, and afterwards dealt with. The cooler is not generally used, but as it aërates, sweetens, and helps the milk to keep much longer, it ought to be universal. In summer some producers heat the milk to 130°, and afterwards cool it from 65° to 75°, this process enabling it to keep sweet still longer. The two best cooling systems are those known as Lawrence's and Dr. Bond's, the latter machine being called the Temperer. It resembles two pairs of lenses placed with the concave surfaces together; the milk enters at the top and runs over the convex outsides until it reaches the bottom, being both aërated and cooled, the lenses being filled with water. In the Lawrence the milk travels over a series of tubes also filled with cold water, but in this instance the water enters at the bottom; consequently, the milk at its coldest travels over the coldest water.

Where milk is not sent away for sale, the next process is setting or separating. The principal systems of setting are, first, the open pan, as practised in England and France; second, the Swartz, or ice system; third, the Cooley, or cold-water system; and fourth, the Harden, or cold-air system. In the open-pan system the disadvantages are, quantity of space occupied, the fact that all the cream is not obtained at any season of the year, its slowness, and, in summer time, its constant liability to cause the loss of cream, for within twelve hours it frequently happens that the whole of the milk is spoiled, and has to be thrown away before the milk has entirely risen. The best kind of pan to use for this purpose is the glazed earthenware pan. It is preferable to metal, and cheaper than glass. Milk is sometimes set in open leads, but this is a bad plan, the lead affecting the milk through the action of the lactic acid. The French open pan is slightly different, being deep and

conical; but the milk is suddenly soured before the cream is taken off. The pans, too, are stood upon the floor in streams of running water, which are carried round the milk-room. By the Swartz system ice is necessary, unless water can be obtained under 45° at all seasons. A vat is used, usually, about six feet in length by three in breadth, and made of concrete. This is filled with water, supply and outflow pipes being provided, one at either end. The broad oval cans, holding about three gallons each, are plunged in, when the cream rises rapidly, and can be used in twelve to eighteen hours in a sweet state. Like all cream raised at a low temperature, it is thin, but large in volume. There is some similarity between this and the Cooley system, in which deep cans are plunged into a refrigerator of cold water of from 40° to 50°. These cans are twenty inches high by eighteen inches in diameter, and, unlike the Swartz, are covered by a movable lid, the water being kept out by the air underneath it. Here also the cream rises in twelve hours, and can be seen by the glass let in at the side of the can. It is not skimmed, but the milk is drawn from beneath by a tap at the bottom. Cream raised in this way is not so liable to feel the effects of atmospheric changes, being under water, and although not aërated, the low temperature prevents the development of anything objectionable. The Harden system resembles the Cooley except that air is substituted for water, and cooled by ice placed in the small chamber at the top. The fact that air is cooled quicker than water was the principal cause of the invention. There is a comparatively new idea invented by Richmond, of Colne, in Lancashire. A square shallow pan, holding from thirty to sixty quarts, is used, which has a double lining throughout, with an ice-chamber at one end communicating with the water. There is also a lid made to hold water, so that the milk in the pan is entirely surrounded by cold water. In the centre is a metal plug, which, when lifted, allows the milk to escape from beneath the cream. When these systems were compared in Denmark, the open pan with the Swartz and the Lefeldt separator, while the last-named gave 100 per cent. the open pan varied from between 83 to 95 at thirty-four hours, and the ice-system from 84·9 to 93 at the same period, or 87·8 at ten hours. The Danish centrifugal

machine gave the following percentages more than the pan system at thirty-four hours, namely, May 10th, June 9th, July 13th, August 11th, September 16th, October 14th, November 15th, December 13th, and the other four months, between 8 and 6 per cent., while, as compared with the Swartz system, it gave from 4 per cent. more in April to 28 per cent. more in November; indeed, there is no comparison between any system and the separator. The chief advantages of the Swartz or Cooley, however, over the open pan system are that they are much more expeditious, occupy far less room, obtain sweet cream, and, in summer time, *all* the cream, which the open pan system does not do

Mr. Long then referred to the principal separators in use, the first and best being that known as the Danish, sold in two sizes, a smaller size suitable for small farmers being promised by the the maker, Petersen, of Copenhagen. This machine has a speed of 3,000 revolutions. It works with less power than any other, skims more milk per hour than any, and obtains more butter per cent. The large machine requires two-horse power, and a small one-horse, the former skimming 120 gallons per hour and costing 62*l.* in Copenhagen against 36*l.* 10*s.* for the latter one. The regulator of Professor Fjord enables the worker to regulate the quantity skimmed as well as the quality of the cream, and its speed can be measured at any moment.

The system of skimming and the machine itself were then minutely described, as also that of the Lavel, the best-known machine in this country, which has a speed of 5,000 to 6,000, and skims from forty-five to seventy gallons per hour, according to the number of revolutions, and the power of from one to one and a-half horse used. There is much merit in this machine, but it cannot be modifred in size or shape, and in the recent competitions in Denmark, where it was beaten by the Danish, it did not skim the fat so completely or work with so small power relatively as that machine. The Petersen, of Hamburg, was next dealt with, this having vertical drums, one or two of which can be worked upon a single shaft, both in large and small sizes. The drums are almost lenticular in shape, and skim from fifty to 100 gallons per

hour, with a consumption of one to one and a quarter horse-power. The trial in Hamburg witnessed by the lecturer was much more satisfactory than at the Royal at Reading, more fat being obtained, and the whole working eminently satisfactorily; but good as the machine is, its price is so high that it cannot well compete with others. The Nakskov, a new Danish make, was then explained. This appears to be worked by a horse, skims from thirty-five to forty gallons, leaves only 1·4 per cent. of fat, and costs 28*l.*, some of the farmers who have worked it in Denmark expressing great satisfaction with it, but it does no such complete work as the Petersen or Danish machine, although it undoubtedly has a future before it. The other machines referred to were the Lefeldt, the first ever made, the Fesca, and the Solid, made by a Swedish engineer.

Cream-raising was then dealt with, and it was stated that, whereas in open pans cream can only be obtained in the hottest weather in twelve hours, it can be skimmed for forty-eight in winter; but if antiseptics, such as glacialine, are used in summer, a difference of some six hours is made, although even then cream is lost. The first cream, or that raised at twelve hours, is always the best, and there is no comparison between butter made from it and that made from subsequent cream. It will be remembered that in winter cream is thin, and in summer thick; this is accounted for by the influence of the temperature, which causes the fat, always most susceptible, to expand or contract. In summer the fatty globules expand to such an extent that they coalesce in rising, and so carry less milk with them, but in winter they contract, and are entirely surrounded in their ascent by milk, thus increasing the volume of the cream. So it is in the system of scalding, which can be done either when the milk leaves the cow, or at the end of twenty-four hours. Where butter is made from sweet cream it yields a less quantity per cent., but keeps better, and develops a richer flavour; this being believed to be caused by the partial decomposition of the cream in the process of souring, hence the preference of some people for sour or lappered cream, as it is called. The Danes invariably sour their cream artificially after having obtained it sweet. In the same way the Normans sour their

cream, but before it is taken from the milk, although after it has risen. Ice was then referred to as being of great value in the dairy, and it can be kept for a long period, the Danes and Swedes saving sufficient for two summers, packing it in a small building or brick yard, and covering it extensively with sawdust. Twenty-five cows would require for one summer twenty-five tons of ice by the Swartz system, and this quantity could be packed in a space twelve feet square.

In describing the aspect, position, and formation of the dairy, Mr. Long referred especially to drains, which should on no account be present, the water being carried out either under the door-sill or through a hole in the wall into another compartment, where the drains should preferably be situated. The floor should be of concrete, and the shelves of slate or wood, unless the Norman system is adopted, when the deep pan may be stood in a gutter, two feet wide, carried down the walls, a stream of water running through, or unless revolving stands are used on which three tiers of open pans can be placed.

In describing churns he stated that there were two *desiderata* in a churn—a large mouth and facility for cleaning, or absence of internal beaters or arrangements. Given these qualifications, little else rested in the churn, but in the person working it, for a good man would obtain the best results with almost any good churn in existence; and it should not be forgotten that if equal quantities of the same cream were placed in three similar churns and worked by the same mechanical power, it would almost invariably be found that different quantities of butter would be obtained, and yet while there is so little certainty about churning, the churn is often blamed without cause, and prizes are often awarded to one churn over another upon no other basis than a result which might be changed the very next day, and which can under no conditions be controlled.

VARIATIONS

IN

THE QUALITY OF FOOD.

By PROFESSOR H. TANNER, M.R.A.C., F.C.S.

A LECTURE

DELIVERED BEFORE

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VARIATIONS IN THE QUALITY OF FOOD.

It was my privilege, in 1877, to carry out an inquiry for the Lords of the Committee of Council on Education, into the variations existing in our several kinds of corn, with the object of tracing out the causes of these variations, so that the information might be made useful for educational purposes. I have thought that it may be useful, if, on the present occasion, some of those results are brought under consideration.

The specimens of corn were taken under my own inspection in various parts of Great Britain, and I had the good fortune to have the valuable co-operation of an analyst of eminent rank in the person of my friend Mr. G. W. Wigner, the President of the Society of Public Analysts.

With his full concurrence I not only withheld all information as to the history of the specimens until the chemical examinations were complete, but I also introduced duplicate samples so as to check the accuracy of the work. The results were in the highest degree satisfactory to me, and I had convincing proofs of the accuracy of the entire series of analyses.

It may now be convenient if I draw attention to some of a large series of coloured diagrams, which I prepared for the Science and Art Department, for the purpose of illustrating the results of that investigation. These diagrams I hope you will more closely examine after the lecture.

In each case the "conditions of growth" are detailed, and it will be seen that the specimens of corn were so selected that they should be fairly contrasted with each other. Each pair of specimens

differed from each other on some one condition only, and thus some one distinct and definite lesson was sought to be learnt. The results are shown in three distinct forms. *First* we have the chemical analyses shown in the usual form—and these will be clearly understood by one class of students. In the next place the production of food, as proved by the analyses, is shown in its practical relationship to the soil, and is calculated for one acre of land in each case. Besides this we have coloured spaces prepared to definite scales, and by varying the colour we see the relative proportions of each group of substances at a glance. Thus we meet the requirements of various classes of students.

The object which was sought to be attained by this research was to determine the extent of variation which existed in the corn grown in this kingdom, and, as far as possible, to trace these variations to their respective causes. The opinions entertained by millers and farmers as to the variations in the quality of corn found no counterpart in the evidence which had been given by chemical analysis. It was also recognised amongst professional chemists that very few of the analyses which had been published could be relied upon, because chemists had fallen into the error of calculating the entire quantity of nitrogen present as being in a form capable of producing flesh. The estimates of the flesh-forming matter in wheat—and other agricultural produce—were known to be largely in excess of the truth. This fact went very far to show that the opinions of experienced millers and farmers were more likely to be correct than the various chemical analyses appeared to indicate. One of the most interesting results of this inquiry has been to confirm in a very marked degree the truths derived from practical experience, and also to show that in the use of chemical analyses there is a great liability to error unless the results are carefully considered in connection with the yield of the crop from a given extent of land. This was found to be the case not only in reference to the examination of wheat, but also with barley and oats, to which the inquiry was extended. In the prosecution of this inquiry attention was first directed to an examination of those samples of corn which showed the greatest variation in the weight per bushel.

Heaviest and Lightest Wheat.—The heaviest sample of wheat grown in this country in 1877 which came under examination weighed 67 lbs. per bushel, and the lightest specimen weighed only 54 lbs. It will be remembered that 1877 was a cold and somewhat unfavourable season for corn. The chemical analyses of these samples gave the following result :—

	Heaviest Wheat.	Lightest Wheat.
True albuminoid matters (gluten)	7·89	10·15
Starch, gum, &c.	74·17	69·03
Fatty matter	1·23	1·61
Cellulose	3·02	4·06
Nitrogenous matter (not true albuminoids) containing nitrogen	·64 (·101)	1·13 (·178)
Alkaline salts in ash	·45	·67
Earthy salts in ash	1·06	·85
Siliceous matter in ash	·12	·39
Water	11·42	12·11
	100·00	100·00

An examination of these analyses shows the percentage of albuminoid—or flesh-forming—matter, to have been higher in the lightest sample of wheat than in the heaviest sample. If our estimate of its value were based simply upon this point of character we should fall into error, and especially if we disregarded the proportion of the fat- and heat-producing matter present in the forms of starch, gum, and fat. In other portions of this inquiry a similar increase in the percentage of flesh-forming matter *in very small crops* has been found, and it is probable that, from some cause or other, the plant being unable to produce *a larger number of bushels* per acre, there was a certain concentration of this flesh-forming matter in the smaller yield. It also appears to indicate an unsuccessful effort on the part of the crop to yield a produce of higher quality, and that, whilst there was a good supply of material for the formation of flesh-forming matter, there was a deficiency in the materials, or the conditions, necessary for the production of fat- and heat-producing matter. The conditions of growth were evidently very imperfectly balanced, and it is more than probable

that if the plant could have accumulated more starch, gum, and fatty matter, the weight of the grain would have been increased. As a matter of fact there was a deficiency of this starchy matter, and as a consequence the analysis of this sample gives the highest percentage of flesh-forming matter in the entire series of the wheats examined, and the lowest in the fat- and heat-producing matter. This peculiarity in composition may be fairly attributed to *the imperfectly balanced conditions of its growth*, but it must not for a moment be imagined that this large percentage of flesh-forming matter is, under the circumstances, desirable.

There was a very considerable range in the quantities of food produced by various crops of wheat. The largest crop grown in 1877 which we examined yielded 60 bushels of wheat per acre, weighing 63 lbs. per bushel. The smallest crop produced only 8 bushels per acre, weighing 57 lbs. per bushel. The chemical analyses of these samples gave the following results:—

	Largest Crop.	Smallest Crop.
True albuminoid matters (gluten)	6·77	6·27
Starch, gum, &c.	72·81	73·91
Fatty matter	1·38	1·06
Cellulose	3·20	1·92
Nitrogenous matter (not true albuminoids)	2·38	3·25
containing nitrogen	(·376)	(·513)
Alkaline salts in ash	1·27	·63
Earthy salts in ash	·52	1·12
Siliceous matter in ash	trace	·40
Water	11·67	11·44
	100·00	100·00

It is a curious fact that these two analyses give the two lowest percentages of albuminoid or flesh-forming matter in the entire series of the wheats examined. The smallest crop of wheat carried the lowest percentage of flesh-forming matter in that fully matured condition which, as albuminoid matter, is considered capable of being formed into flesh, but it also carried one-third of its nitrogenous matter in an imperfectly matured condition. Its conditions of

growth being in many respects unfavourable will easily account for this fact. It may be remarked that the late period at which it was sown caused an imperfect and sluggish growth of the plant, and the high condition of the land appears to have forced into the plant nitrogenous matter which it could not bring into a fully matured form. These conditions of growth are entirely different from those which were explained in the case of the lightest wheat, and do not conflict with them. In the former case the crop was checked and its produce of corn rendered inferior, because the plant wanted supplies which it could not get; but here there are supplies which the weak and imperfect condition of the plant did not allow it to make use of.

The small percentage of flesh-forming matter in the largest crop of wheat may be fairly traced to the fact that the rapidity of growth was so great that the flesh-forming matter was diffused through a very large number of bushels of corn, and there was consequently less opportunity for rendering the wheat as perfect as it would otherwise have been. These are considerations which naturally present themselves in examining the chemical analyses of these samples; but when the more practical results are dealt with, the facts are much more easily appreciated. In the following table the quantities are given of the food produced from one acre of land by each of these crops:—

PRODUCE FROM ONE ACRE OF LAND.

	Largest Crop.		Smallest Crop.	
	lbs.	lbs.	lbs.	lbs.
Substances useful as food—				
Flesh-forming matter	256		28½	
Fat- and heat-producing matter	2804½		341¾	
		3060½		370¼
Substances of little or no use as food—				
Cellulose, &c....	211		23½	
Mineral matter	67½		9¾	
Water	441		52½	
		719½		85¾
		3780		456

In the case of the largest crop of wheat, the flesh-forming matter produced per acre was nine times as great as in the case of the smallest crop. If we notice the variations in the fat- and heat-producing matter formed in the two cases, we find it eight times as great in the largest crop as it is in the smallest.

Our limited space prevents the details being as fully shown in the examination of barley and oats. The heaviest sample of barley grown in 1877 weighed 60½ lbs. per imperial bushel, and the lightest only 37 lbs. There was therefore a range of weight equal to 23½ lbs. per bushel in this variety of corn. As compared with the variations observable in the weight of wheat grown in the same season, the range is found to be greater in that of barley; the proportion being 13 lbs. for wheat to 23½ lbs. for barley. This is by no means an exceptional result, as common observation shows that the variation is usually greater in barley than in wheat.

The chemical analyses of these extreme samples of barley were as follows:—

	Heaviest Barley.	Lightest Barley.
True albuminoid matters (gluten)	7·66	4·18
Starch, gum, &c.	71·88	71·43
Fatty matter	·78	1·30
Cellulose	3·23	3·67
Nitrogenous matter (not true albuminoids)	·89	1·08
containing nitrogen	(·140)	(·171)
Alkaline salts in ash	1·58	1·01
Earthy salts in ash	·57	·73
Siliceous matter in ash	·32	1·62
Water	13·09	14·98
	100·00	100·00

The specimens, it will be seen, differed very greatly in the percentage quantities of the albuminoid, or flesh-forming matter; and thus, *in an equal weight* of these samples of barley, the heavier barley contained considerably more nutritive matter than the lighter sample. In order, however, that this variation may be fully recognised, it is desirable to show how far this influenced the

production of actual food for an equal area of ground. In the case of the heaviest barley the produce was 36 bushels per acre, whilst the yield of the lightest barley was 33 bushels per acre, but the flesh-forming matter produced per acre was 167 lbs. as against 51 lbs., and the fat- and heat-producing matter was found in the proportion of 1,582 lbs. as against 888 lbs.

We may now notice the comparative feeding value of the heaviest and the lightest oats grown in 1877. Here we had six times as much fat- and heat-producing matter, and twenty times as much flesh-forming matter produced from the same extent of land. We found one acre of land producing nearly fifteen times as much fat- and heat-producing matter, and nearly seventy times as much flesh-forming matter, as another acre of land, thereby indicating a very extensive range in the production of food from a similar extent of land.

The influence exerted upon the quality of the yield of oats, by the *more or less perfect drainage of the land*, was also examined. The produce of two fields, having soils of similar character, and situated under similar conditions of climate, was found to differ as follows:—The land which had been properly drained yielded 38 bushels of oats per imperial acre, weighing 42½ lbs. per bushel, whilst the undrained land gave only 26 bushels of oats, weighing 37 lbs. per bushel. The acre of land which was drained produced 126 lbs. of flesh-forming matter as against 67½ lbs. on the undrained, and 949½ lbs. fat- and heat-producing matter as against 570 lbs.

The inquiry was also extended so as to include those cases in which by *skilful management* difficulties of soil and climate were surmounted, and to show the influence which was thus exerted upon the production of food. In one case we found the good and the bad management of land, fairly similar in natural character, and under similar conditions of climate, producing crops exceedingly different in quantity and quality.

The production of food in these instances also showed how greatly good cultivation enables the yield of corn to be increased in quantity, at the same time that it becomes of greater value per bushel. The composition of the oats produced upon each imperial acre may be stated as follows: under good cultivation 154½ lbs.

flesh-forming matter was produced as against 3½ lbs. under bad cultivation, and 1388 lbs. of fat- and heat-producing matter as against 145 lbs.

Every farmer is acquainted with the fact that a favourable or an unfavourable seed-time materially influences the character and quality of the crop. I considered it desirable to render the evidence of practice somewhat more definite, and in the course of inquiry an opportunity offered for doing so. A field having a good loamy soil was prepared for sowing in the usual manner. The same seed was used throughout the field, and the conditions of growth were similar with one exception, namely, one portion of the field was sown in good condition, and on the other portion the sowing was interfered with by a heavy fall of rain, which caused that part of the field to work badly. Where the seed had been sown whilst the land was in good condition the crop commenced its growth well, and continued to progress favourably, until at harvest it produced 40 bushels of barley per acre, weighing 58½ lbs. per bushel. Upon the portion sown during the fall of rain, and whilst the land worked badly, the growth was never satisfactory, and the yield at harvest was only 24 bushels per acre, weighing 54 lbs. per bushel.

The chemical analysis of these samples of barley gave some curious results which demand a notice in passing.

ANALYSES OF BARLEY.	Good Seed-time.	Bad Seed-time.
True albuminoid matters (gluten)	7·29	7·92
Starch, gum, &c.	70·95	73·02
Fatty matter	1·39	1·27
Cellulose	3·70	2·06
Nitrogenous matter (not true albuminoids) containing nitrogen	·68 (·107)	1·14 (·180)

Here we see the barley grown under a bad seed-time yielding the better results on analysis, and a mere theorist might rush to the conclusion that it would be a desirable plan for the improvement of corn. No man who had a fairly sound practical knowledge

of the feeding value of corn would have given a preference for that sample, even when backed up by the authority of the analysis. I have reason to know that the analyses are accurate, and I am rather disposed to regard these growths as some of those typical cases which show that even accurate analyses must be judiciously employed.

One of the most interesting, and probably one of the most important, influences affecting the production and the quality of oats, is that exerted by the seed. We found land of similar character and under similar conditions of climate, producing crops differing from each other in a very marked degree, and in one selected case that variation was fairly traceable to the influence of the seed.

The produce obtained from the seed having a good character was 35 bushels of oats per imperial acre, weighing 41 lbs. per bushel, whilst the seed of bad character produced 22 bushels, weighing 20 lbs. per bushel. The composition of the produce of one acre of each of these crops showed seven times as much flesh-forming matter, and three times as much fat- and heat-producing matter, as the gain arising from the use of seed having a thoroughly good character.

In speaking, however, of seed of good or bad character, I do not simply refer to that external appearance or condition which is generally observable, but also to that hidden constitutional character which subsequently enables the plant to struggle successfully against difficulties of growth. It is well known that seeds which differ but little in appearance may have constitutional powers which will manifest themselves in unfavourable seasons, when the plant has to contend with adverse conditions. Nor must we limit the evidences of these influences to unfavourable seasons, although they give under such circumstances undeniable proof of their power, but we should, on the other hand, constantly acknowledge the truth of this hidden influence. In dealing with animal life we readily admit that we can intensify, and render more permanent any desirable points of character. In vegetable life something has been done to establish in seed those distinctive characteristics which we desire to perpetuate, but very much more yet remains to be accomplished.

Closely associated with this influence is that which arises from "change of seed," by which is generally understood making use of a suitable seed grown in another district, or upon soil of a different character. In the case examined we found that the crop of oats grown after a "change of seed" yielded more than three times the quantity of available food than was produced in another crop grown under the same conditions of climate and soil, when this influence was neglected.

If we now for a moment compare the general results of our corn analyses with those usually accepted, we see the variations in quality shown in the following table:—

	ALBUMINOIDS OR FLESH-FORMERS.		
	Percentage usually accepted.	Percentage gradually falling to	Highest percentage found in 1877.
Wheat	13·	6·27	10·15
Barley	9·	4·18	9·06
Oats...	12·	1·58	9·48

We found the feeding power becoming more and more degraded just as the management sunk from bad to worse, and an unfavourable season did not permit the best results to be obtained.

But these remarkable variations are not limited to our corn crops. All who are accustomed to the care of cattle and sheep whilst they are feeding upon root-crops, are more or less fully acquainted with the fact that these crops differ greatly in feeding-value. Our best information is still exceedingly limited respecting those variations in composition which cause the differences so generally observed. In far too many cases the total weight per acre is taken as being quite sufficient to determine whether the growth of a crop has been satisfactory or otherwise. The experimental trials of various manures have been very generally determined, simply by the test of the weight of the produce per acre. One object, which is now aimed at, is to furnish proof that the weight of produce per acre is not only an insufficient test, but it

is rather calculated to lead to erroneous conclusions and an enormous loss of food.

The practical experience of the stock-keeper may be confidently appealed to on this point, for each and all have observed instances of roots differing from each other in their feeding characters. Two crops of swedes, possibly growing in adjoining fields, may appear to the eye to represent fairly equal weights per acre, and yet the one may feed an equal number of sheep for a much longer time than the other, and also enable them to make more progress. It is always a source of satisfaction when the roots are so solid and so well grown, that sheep cannot make rapid headway over the field. On the other hand, there is generally a feeling of disappointment if sheep clear the ground with unusual rapidity. It not only appears to indicate a large consumption of food, but it is generally accompanied by a still more unfavourable condition, viz. that the food used possesses very little good feeding quality. Another difference, which is commonly observable under such circumstances, consists in the greater feeling of satisfaction and contentment shown by stock after feeding upon solid, well-grown swedes, than when feeding upon others destitute of such qualities. When stock are fed upon roots of the latter description (unless they have other food to compensate for, or hide from our observation, their feeble feeding powers), however much of the crop they may consume, they generally appear restless, and show a desire for more food.

The experience of practical men may also be appealed to upon another point, namely, as to the varying density of roots. A farmer in handling a swede can generally form an approximate opinion as to its feeding value. If he finds it heavy in proportion to its size—or, as we may otherwise describe it, as dense, or possessing great density—he knows perfectly well that a well-grown root possessing this character is sure to be good food. If, however, he finds it relatively light in the hand, and having little density, he is equally sure to condemn it as being of inferior feeding character. So also an opinion is often formed by gently striking a root with the foot or with a stick, for we then obtain another evidence of its greater or less density. The sound coming from a firm and well-grown root is very different from that given

by one which has little density. I had a singular proof of this accuracy of judgment, as shown by experienced farmers, in a case reported by Mr. Sydney Buckman and myself in *The Agricultural Gazette* of November 18, 1878. I was about to test a large number of mangolds grown experimentally on Professor Buckman's farm, and I was surprised by his bailiff, Mr. Sherrin, stating that he could tell which were the best without my weighing them. I was very pleased to find when the weighings were completed that he was quite correct, for it was additional evidence of the sound judgment possessed by men of extended agricultural experience. These facts are, however, so generally recognised by all experienced men, that giving them in such detail almost calls for an apology.

But in the face of this knowledge, we find the lessons so taught, and the truths thus recognised, are very generally disregarded. What is more common than to consider a manure which produces (say) 25 tons per acre, as better than another manure which may have produced 20 tons? I am ready to admit that many practical men would quietly challenge such a decision, and even go so far as to give a preference to the smaller weight, when the quality is better. Still, these cases are rather exceptional, as it is the almost invariable opinion that the manure which has produced the heaviest crop of roots is the best. If any proof of this were needed, it is readily obtained by reference to the records of field experiments which have been published, and to the awards of prizes given by various Agricultural Societies. It is, therefore, a great source of surprise that, whilst every farmer knows that one ton of swedes, or turnips, or mangolds, may differ greatly in feeding value from another ton, the truth should be so generally lost sight of in experimental research, and in the awards of prizes.

We are all too apt to overlook the fact that our root-crops are all artificial modifications of plants, which by careful selection and cultivation have taken an entirely unnatural form, but one which is nevertheless very desirable. If we compare our well-cultivated mangold with the wild sea-beet from which it has been obtained, we cannot fail to be surprised at the change in form and character which it has undergone. After this great variation has been accomplished, it is very much more easy to make that vegetable growth more or less nutritious at will. Its earlier growth may be

familiarly compared to the construction of a large number of cells, ready to act as store-rooms for richer food. By taking the density of these roots we can judge whether these store-rooms are full or only partially utilised, and this conclusion is closely arrived at by the experienced hand, or more accurately by weighing, so as to determine the density or specific gravity. This close connection between the density of roots and their feeding power is not simply a matter of popular belief.

Holding this opinion as I did in common with other practical men, I sought for direct confirmation of its truth by careful research; but in order that this may be clearly explained, it is desirable to show the course of procedure adopted in order to arrive at an accurate knowledge of the density of any of our roots.

It will be readily understood that although a person may handle a swede, turnip, or mangold, and form a fairly approximate opinion as to the quality of either, it is impossible to determine their relative value when they approach towards one common degree of merit. Hence such observations have to be reduced into figures by careful weighing, and this is easily accomplished by determining their relative weights for equal bulks, or, in other words, by taking their "specific gravity," as it is technically termed. A large proportion of our root-crops may be easily separated into two very distinct groups, by placing them, one by one, in a large trough filled with water. Those which float will orm one group, whilst those which sink in the water will form another group, and it will be found that the latter possess greater feeding power than the former. But amongst those which sink in the water, it is probable that we shall find distinct variations in quality, and these variations will be found to correspond very closely with their respective "specific gravities." Hence, although we can easily separate the bulbs into two groups, as they may float or sink in water, if we desire to classify these groups more completely, it must be done by weighing them in water.

Each root has to be weighed twice—once in the ordinary way, and secondly, when suspended in a cask—or other vessel—of water. This is usually done by having two sets of scales on a table, whilst placed at one end of that table, and level with it, is a cask filled with water. One pair of scales, constructed with a

beam, is so placed at the end of the table, that one end of the beam projects over the cask of water, and thus a swede, mangold, or other root can be suspended from it, so as to hang freely in the water. Its weight is then carefully taken.

Few facts are more surprising to those who have not had experience in such work, than the differences observed in weighing even a good swede on an ordinary pair of scales, and then in water. Take, for example, a good swede weighing 12 or 13 lbs.; when it is suspended in water it may only weigh a quarter of a pound, or perhaps 5 ozs., and as swedes are generally grown, it will in most cases weigh less than this. In fact, it is by no means uncommon for a small and solid swede to weigh heavier in water than larger grown specimens. By taking the weight of a swede in the ordinary way, and then calculating how much weight it loses by being weighed in water, we have all the details which we need to settle the "specific gravity." A swede, for instance, which weighs 12 lbs. (or 192 ozs.) may when suspended in water only weigh 4 ozs.; we have therefore a loss of 188 ozs. To calculate what is the specific gravity, we divide the original weight (192 ozs.) by the loss of weight (188 ozs.), and the result (1·021) shows the specific gravity. If we took another swede weighing, say, 10 lbs. (160 ozs.), and suppose that this weighed 4 ozs. when suspended in water, here we have a loss of 156 ozs., and the specific gravity would be calculated as 1·025. The probabilities are that the smaller swede is the more valuable as food. The experiments whereby this popular idea received confirmation were carried out by Mr. John Hill (of Felhampton Court, Shropshire) and are in a Report addressed by Mr. Hill to the members of the Marshbrook Agricultural Improvement Society, of which he is the president.

This Report is especially valuable, as showing the remarkable manner in which the density of the swede (when properly matured) corresponds with the *available* flesh-forming matter it contains, or, in other words, its meat-producing power. Attention is drawn to the loss arising from a want of judgment or care in the ripening of the swede, for it is quite possible to throw into a swede a large quantity of nitrogenous matter, which ought to be ripened into *available* flesh-forming matter, but until that root has been properly matured, such matter, if used as food, is not only not useful, but

positively injurious. In the Felhampton experiments, care was taken to allow the swedes to become properly matured before they were tested. So far as my examinations have gone, it has been found that, with properly matured roots, the higher their specific gravity, the more perfect are the feeding powers they possess.

Another very important illustration of the errors so commonly made in the award of prizes for roots, presented itself at the Reigate and Redhill Agricultural Society's Show in December 1881. The Society's prizes were very fairly awarded for the several kinds of roots, on the conditions usually observed in our Agricultural Exhibitions—namely, excellence in form, external appearance, and weight. But a second set of prizes having been offered by Mr. St. Barbe Sladen, President of that Society, for the best quality of roots in each of these classes, *as determined by their weight in water*, it happened that in every instance the award fell to a different lot of roots from that gaining the Society's prize. Naturally enough, this caused much surprise, and it was ultimately determined to send the two sets of prize roots in one class for careful examination and analysis.

The general result shown by these analyses is that 100 tons of the Sladen prize-roots contained as much solid matter as 150 tons of the Society's prize-roots. In addition to this, we found that 100 tons of the Sladen prize-roots contained as much sugar as 280 tons of those which gained the Society's prize. There does not appear to have been any reason to consider these differences in quality as in any way exceptionally large, but we may learn from these analyses how enormously overcharged with water is much food which is given to stock. If we were in the present case to assume that the dry matter of the two lots of mangold had been equally good, we find 50 tons of water needlessly passing through the stock-consuming 150 tons of the Society's prize mangolds. This water had to be raised to the temperature of the body, much of it had to be evaporated from the animal, and thereby much of the remaining sugar would be used up in discharging a perfectly needless duty.

These Sladen prize-roots must not be looked upon as being as good as they might have been, still they very well illustrate this great truth, that so long as external appearances and total weight

per acre continue to be alone regarded as evidences of successful management, so long the culture of our root-crops is likely to remain unsatisfactory. The object to be attained is the production of *the largest weight of actual food*, and not the greatest weight of water brought into a portable form by the aid of vegetable life. A consideration of the *quality* of the food produced should be no longer kept in the background, and one of the first steps to encourage attention to quality would be to prohibit any root which will float on water from contending for a prize, under any Agricultural Society. Up to the present time the tendency of our Agricultural Exhibitions and prizes has been to encourage some of these serious errors of practice, against which the experience of stock-feeders offers a standing protest.

As soon as the endeavour is made to produce the largest quantity of FOOD, of the best quality, by means of root-crops, we shall find many singular departures from the existing systems. When the effort is made to increase the percentage of actual food, we shall find a perfectly different class of roots produced. It is well known that when beet is grown for the manufacture of sugar, care is taken to keep the roots small in size, and tolerably thick on the ground; and thus a much larger percentage of actual feeding material is obtained from the roots grown. So also in the growth of the garden-beet, the effort is to secure produce of the richest quality. If this question of quality were lost sight of by the gardener, however much he might pride himself upon the large size and the weight of Garden Beet obtained, he would soon be told that he had spoiled it for use as food. In our competitions for farm-produce of a similar kind, the question of QUALITY has also been lost sight of, and the consequence is, that having turned into an indigestible form much that previously existed as good food, we load it with an excessive quantity of water, and pride ourselves upon the splendid growth which has been secured. As soon as the feeding power of the food produced is made an essential of success, so soon shall we find the present practice completely changed. It needs no argument to support the plea, that when the production of food is the declared object of the cultivator, the feeding character of the produce is entitled to the first consideration. We naturally desire to grow as large a weight of crop as

possible, but no one can justify the imprudence of an over-growth which decreases the quantity of food previously existing in that crop. When once this truth is recognised, we shall soon find measures adopted to prevent this waste of food. The adoption of Two Rules by our Agricultural Societies would soon secure the more perfect growth of our root-crops.

First.—Every root which floats in water should be thereby disqualified from competing for any premium or prize.

Second.—All prizes for roots or root-crops should be awarded with due regard to Three Conditions:—

(*a*) The highest feeding-value.
(*b*) The greatest weight.
(*c*) The best form.

When these rules are practically recognised, we shall soon find that much of the agricultural research of the past will need revision, because the variations in the feeding quality of the produce have been so seldom taken into account. The enormous mangolds, which are now the pride of so many exhibitors, will also be thought of with a smile, as very perfectly exhibiting how large a quantity of good food it is possible to waste by the aid of a single plant.

Some other lessons, however, may be drawn from these facts. Never undervalue practical experience. He who speaks of farmers as ignorant men is sure to be ignorant of farm practice, and therefore not competent to judge. As learners, and as teachers hereafter, value very highly the boundless source of knowledge we have in the experience of practical farmers. In the next place learn also that practical skill may be advantageously supplemented by science, but you should never let purely theoretical notions supersede the teachings of experience. Science is as a light to the skilful workman, but remember that light does not give to a novice business experience.

This inquiry also shows us that bad cultivation, bad seed, badly drained land, bad management, and, last but not least, bad seasons, all tend to degrade the feeding-value of farm produce, whilst good cultivation, good seed, good drainage, good management, and good seasons, enormously increase the production of food, and improve its quality.

THE INSTITUTE OF AGRICULTURE,

SOUTH KENSINGTON, LONDON.

Established for the purpose of advancing Technical Instruction upon various sections of Agricultural Practice, as a preparation for learning the business of Farming, and especially for bringing these advantages within the reach of any and every person who may wish to avoid the expenses which are at present associated with education of this character. The following course of instruction may be regarded as an important contribution in this direction, and the Council feel exceedingly indebted to those who have, by their cordial co-operation, enabled them to secure the advantages of GREAT EXCELLENCE and GREAT ECONOMY.

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REPORT OF COUNCIL.

SESSION 1883-4.

THE extended success of the Institute of Agriculture is a source of great satisfaction and encouragement to the Council. The Session which has just closed has given increased evidence of the necessity for the work in which they are engaged, and of its high appreciation by those attending the classes. Amongst the events of the Session, the Presidency of HIS ROYAL HIGHNESS THE PRINCE OF WALES, on the occasion of the delivery of Mr. H. WOODS' Lecture on "Ensilage," must be mentioned as having rendered very valuable assistance to the Council, and to those engaged in the work of the Institute. It should be noted that an extended course of study has been brought into operation during the past Session. Three Students have attained the rank of "Associates," each having secured by a long series of successful examinations "The Diploma for Agricultural Science." In addition to this, no less than 102 First-Class Certificates were gained by the 324 Students after stringent examinations, besides many others of less value.

The Lords of the Committee of Council on Education having kindly granted the use of the Lecture Theatres in the South Kensington Museum and in the Museum of Geology in Jermyn Street, London, there will be a material extension of the work to be done in the next Session, details of which will shortly appear.

Assistance will also be rendered to Provincial Committees desirous of having, in their own localities, Technical Lectures and Examinations upon the various details of Farm Industries.

The increased success of the Institute of Agriculture must, however, after all, depend in an important degree upon the contributions and general assistance of those who are interested in the promotion of Agricultural Education amongst the future occupiers of land in this country. The advantages which are likely to arise to the owners of landed property from such help being given are tolerably obvious, for the tenantry of the Kingdom are not now able to compete on fairly equal terms with their BETTER EDUCATED COMPETITORS in other countries. Not only are Male Students in most European countries, and in the United States, educated in the sciences connected with the culture of the soil, but Females also are regularly trained to become experts in the management of the Dairy and Poultry, as well as other Minor Food Products. As a consequence, many imported articles of food are superior to those of Home production.

The Government Science Classes for Instruction in the Principles of Agriculture are giving valuable help, but these classes do not, and are not intended to, meet the full requirements of the TECHNICAL INSTRUCTION which is needed. A most important advantage is gained by such Government assistance, if year by year, some thousands of Students are passed from these classes, prepared for, and desiring a higher and fuller course of instruction. During the Session of 1883–1884 upwards of seven thousand Students attended these classes on the Principles of Agriculture, and hence that work has assumed a thoroughly national character, whilst the official reports show that excellent work is being done by them. It is true that there are two very superior Colleges of Agriculture existing in this country, for providing instruction in the Science and Practice of Agriculture for the sons of the more wealthy classes; but, notwithstanding this fact, the great majority of the rising generation of Tenant-farmers are absolutely without any means for education in the higher branches of Agricultural Science, because the necessary charges in these Colleges (120*l.* per annum and upwards) are

practically prohibitory for the children of the great mass of the Tenantry of this Kingdom. These Colleges have a great work before them in providing instruction for those who naturally claim the highest, the best, and the most complete instruction in agriculture; but the THOUSANDS have to be cared for as well as the TENS, and the welfare of those practically engaged in this great industry urgently demands prompt consideration. A comparison of our own educational arrangements with those possessed by other countries will show the deficiency under which this Kingdom suffers, and towards the amendment of which The Institute of Agriculture is intended to contribute.

	Colleges and Schools of Agriculture.	Number of Students.	Students in Agricultural Classes.	Remarks.
DENMARK	100	—	—	All flourishing.
FRANCE	45	1171	—	
AUSTRIA	69	2035	5537	1486 Students of Bee Culture.
UNITED STATES	39	4211	—	473 Professors and Assistants.
GERMANY	158	—	17,844	Probably over 5000 Students in Colleges.

Norway, Sweden, Belgium, Switzerland, and Italy are also working actively in the promotion of cheap agricultural education, and in very few cases, if any, is the cost any impediment to study. The position of matters is very different with ourselves.

	Colleges of Agriculture.	Number of Students.	Students in Government Classes.	Students in Institute of Agriculture.
ENGLAND...	2	150	Nearly 8000	324

The Institute of Agriculture is, therefore, helping to provide at a small cost, a thoroughly sound and good course of ADVANCED TECHNICAL INSTRUCTION IN AGRICULTURE, which shall usefully supplement the work in the Government Science Classes. Now that the Central Institute has been established, assistance will be

rendered to Provincial Centres in different parts of the Kingdom, and these advantages will thus be made more generally useful.

With all our disadvantages in this country, we still have invaluable opportunities for practical instruction which need far less supplemental assistance than is necessary elsewhere; but even the most experienced in practice desire for their children, if not for themselves, that additional help which arises from a knowledge of the why and wherefore of past successes, difficulties, or failures; and which shall prepare them for subsequently gaining a more perfect and practical knowledge of their work, in their own Homes, or on their own Farms. It must be remembered that all the educational establishments in other countries, to which reference has been made herein, have received large grants from their respective Governments, and that in the absence of such assistance in this country private contributions are necessary to enable the work to be extended with promptitude and efficiency. It will greatly strengthen the hands of the Executive, if those who are willing to contribute towards the funds necessary for the extended work of The Institute of Agriculture, will direct that their subscriptions shall be placed at the disposal of the Council with as little loss of time as possible. Cheques should be made payable to the account of The Institute of Agriculture, in the London and County Bank, Queen's Gate, London, S.W.

It now only remains for the Council to tender their thanks to the Lords of the Committee of Council on Education for the assistance they have rendered in the past, and for the privileges again granted to the Institute—to the Trustees of the British Museum for Lecture Room accommodation, as also for the facilities granted for the practical demonstrations with Bees upon their grounds in South Kensington—to the Society of Arts for the kind accommodation so cordially rendered for the meetings of the Council and Committees—to the Council of the Royal Veterinary College for their consent for members of their staff rendering valuable co-operation—to Professor Tanner for his gratuitous assistance during another year—and last, but not least, to the Lecturers who have so ably and liberally assisted the Council in their work.

LECTURES FOR THE SESSION 1884-5.

IN THE LECTURE THEATRE OF THE MUSEUM OF GEOLOGY, JERMYN STREET, LONDON.

(*By permission of the Lords of the Committee of Council on Education.*)

January 5th to 17th, 1885.—A course of twenty Lectures upon "Chemistry in Relation to the Soil," by Bernard Dyer, Esq., F.C.S., F.I.C.

January 19th to 24th.—A course of ten Lectures upon "Geology in Relation to Agriculture," by William Topley, Esq., F.G.S.

**** *For other Jermyn Street Lectures see subsequent Schedule.*

IN THE LECTURE THEATRE OF SOUTH KENSINGTON MUSEUM.

(*By permission of the Lords of the Committee of Council on Education.*)

January 26th to 31st.—A course of ten Lectures upon "Vegetable Physiology in Relation to Farm Crops," by Professor G. T. Bettany, M.A., B.Sc., F.L.S.

February 2nd to 7th.—A course of ten Lectures upon "Animal Physiology in Relation to Farm Stock," by Professor J. Wortley-Axe, M.R.C.V.S.

February 9th to 14th.—A course of ten Lectures upon "The Chemistry of the Food of Farm Stock," by Professor R. V. Tuson, F.I.C.

February 16th to 21st.—A course of ten Lectures upon "Farm Seeds," by Professor J. Buckman, F.L.S., F.G.S.

February 23rd to March 21st.—A course of forty Lectures upon "Agriculture, Grass Land, and Farm Stock," by Professor H.

Tanner, M.R.A.C., F.C.S.; John Henderson, Esq., F.H.A.S.; Robert Holland, Esq., M.R.A.C.; and other Experts.

March 23rd to 28th.—A course of ten Lectures upon "Poultry Management," by W. B. Tegetmeier, Esq., F.Z.S.

EASTER VACATION.

April 13th to 25th.—A course of twenty Lectures upon "Dairy Management," by James Long, Esq.; P. McConnell, Esq., F.H.A.S.; Bernard Dyer, Esq., F.C.S., F.I.C.; and other Experts.

April 27th to May 2nd.—A course of ten Lectures upon "Bee Management," by F. Cheshire, Esq., F.R.M.S.

*** *The foregoing Lectures will be commenced at* 11 *and* 12.30.

EVENING LECTURES ON AGRICULTURAL SCIENCE.

AT EIGHT O'CLOCK, P.M.

1885.		SUBJECT.	LECTURER.
Feb.	26	English Cart Horses—Their History, Breeding and Management. (*This Lecture is for Gentlemen only.*)	Frederick Street, Esq.
March	2	Nitrogen—its various duties.	R. C. Woodcock, Esq., F.C.S., F.I.C.
,,	9	English and Continental Dairy Systems.	James Long, Esq.
,,	16	Improvements in Farm Seeds.	Murton Matson, Esq. M.R.A.C.
,,	23	Incubators and Artificial Hatching.	W. B. Tegetmeier, Esq., F.Z.S.
,,	30	Fermentation in relation to Agriculture.	R. H. Harland, Esq., F.C.S., F.I.C.
April	13	Honey—its production and storage.	F. Cheshire, Esq., F.R.M.S.
,,	20	Milk in relation to Public Health.	Professor J. Wortley-Axe, M.R.C.V.S.
,,	27	Functions of Roots.	Professor G. T. Bettany, M.A., B.SC., F.L.S.
,,	28	Examination for Certificates.	
May	4	Distribution of Certificates of Merit.	

THE COURSE OF INSTRUCTION.

THIS system of Agricultural Education has been arranged in an exceptional manner for two reasons, amongst others—

First—To enable Students to give their undivided attention to ONE SUBJECT AT A TIME, and as soon as each subject, in rotation, has been satisfactorily dealt with, the Examination upon that subject takes place, and the attention is then directed to some other branch of study.

Secondly—To afford facilities for any persons who may desire to attend ANY ONE COURSE, or more, by concentrating that section of work within the shortest time which is really necessary for a proper study of the subject.

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When Tickets are taken for an entire Session, special seats will be reserved throughout, priority being given in the order of their issue. If from any cause any Lecturers should be unable to carry out their portions of the scheme, the Council can provide substitutes. Donations will be thankfully received for the Fund for assisting deserving persons with Free Tickets, and for contributing towards their Expenses in coming to attend the Lectures.

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Fellows of the Institute.—Associates who, having had fully two years' Farm Practice, subsequent (as a rule) to taking up their Associateship, and are able to pass the required Examinations on the Practice of Agriculture, will be entitled to rank as Fellows of the Institute of Agriculture under THE DIPLOMA FOR AGRICULTURAL PRACTICE.

THE END.

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